5 LISRC #587
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People and the Sound

FLOOD DAMAGE REDUCTION

A Planning Report prepared for the New England River Basins Commission by the U.S. Department of the Army, Corps of Engineers; and the U.S. Department of Agriculture, Soil Conservation Service

New England River Basins Commission

The Long Island Sound Regional Study is a "level B water and related land resources study." It was conducted under provisions of the federal Water Resources Planning Act of 1965. The Plan which has been developed was prepared by a team of federal, state, and regional officials, local citizens, and the scientific community, under the overall coordination of the New England River Basins Commission. It is a part of the Commission's comprehensive, coordinated joint plan for the water and related land resources of its region, which includes New England and the New York portions of Long Island Sound.

The plan for Long Island Sound recommends a program for action by federal, state, and local governments; it does not bind them to undertake specific recommended actions. To assist in the evaluation and implementation process, the following reports have been prepared:

A PLAN FOR LONG ISLAND SOUND: A SUMMARY. Highlights of the plan and a brief discussion of the rationale leading to recommendations.

A PLAN FOR LONG ISLAND SOUND: SUPPLEMENT. A more comprehensive planning document which enumerates the major alternatives considered in formulating the recommendations, together with an explanation of how the plan was prepared, who did the work, and background information organized both by subject matter and by geographical sub-regions of the Study Area.

PLANNING REPORTS. Each planning report was developed by a "Work Group," chaired by a federal agency, with the active participation of state and local agencies, other federal agencies and citizen and scientific advisors. These reports incorporate data (originally published in a series of Interim Reports) which estimate people's demands for the resources of the Sound region, the requirements needed to meet those demands, the existing capacity of the region to meet the requirements, and any deficiencies noted.

The second half of each planning report develops solutions by stating objectives in terms of satisfying defined needs, suggesting alternative ways to achieve the objective, evaluating each alternative in terms of environmental, economic, and social criteria, developing economic, environmental, and composite plans, and finally making recommendations.

The following Planning Reports were prepared:

Water Management by the U. S. Environmental Protection Agency, and the States of New York and Connecticut.

Land Use by Ralph M. Field and Associates for the U. S. Department of Housing and Urban Development.

Outdoor Recreation by the U. S. Department of the Interior, Bureau of Outdoor Recreation.

Fish and Wildlife by the U. S. Department of the Interior, Fish and Wildlife Service; and the U. S. Department of Commerce, National Marine Fisheries Service.

Shoreline Appearance and Design by the U. S. Department of the Interior, National Park Service and Roy Mann and Associates.

Marine Transportation by the U. S. Department of the Army, Corps of Engineers.

Power and the Environment by Federal Power Commission staff.

Mineral Resources and Mining by the U. S. Department of the Interior, Bureau of Mines.

Flood Damage Reduction by the U. S. Department of the Army, Corps of Engineers; and the U. S. Department of Agriculture, Soil Conservation Service.

Erosion and Sedimentation by the U. S. Department of the Army, Corps of Engineers; and the U. S. Department of Agriculture, Soil Conservation Service.

OTHER REPORTS published in conjunction with the Study are:

An Economic Perspective by the U. S. Department of Agriculture, Economic Research Service; and the U. S. Department of Commerce, Bureau of Economic Analysis. An examination of the economic and demographic trends in the region, with data for use as the basis of all projections made in the Study.

Shoreline Appearance and Design: A Planning Handbook by Roy Mann Associates, Inc., for the U. S. Department of the Interior, National Park Service. Recommended management procedures for protecting and enhancing the region's scenic resources.

Sources and Movement of Water by the U. S. Geological Survey, Water Resources Division; and the National Oceanic and Atmospheric Administration. A summary of the hydrology and climate of the region.

Soils by the U. S. Department of Agriculture, Soil Conservation Service. An inventory and analysis of soil composition in the region.

For a complete listing of reports published by or in conjunction with the Study, see Appendix A of the Supplement. Copies of these reports are available from:

New England River Basins Commission
55 Court Street
Boston, Mass. 02108

National Technical Information Service
Springfield, Va. 22151

FLOOD DAMAGE REDUCTION

a Planning Report

Long Island Sound Regional Study
New England River Basins Commission
270 Orange Street
New Haven, Connecticut 06511

A Report
Prepared by the

Corps of Engineers
U.S. Department of the Army

Soil Conservation Service
U.S. Department of Agriculture

January 1975

FOREWORD

Long Island Sound is one of the nation's unique and irreplaceable natural resources. An almost fully enclosed arm of the ocean, it has over 1300 square miles of water surface and over 600 miles of coastline. Spreading eastward along both shores from the great metropolitan center which lies at the Sound's western end, a growing concentration of increasingly affluent people make ever greater demands on this urban sea. At the same time, there is a growing feeling that the conflicting demands are destroying the Sound, and that the problems must be resolved if the Sound is to be preserved.

The Long Island Sound Regional Study is a comprehensive planning effort by the Federal government and New York and Connecticut, led by the New England River Basins Commission. Assisting the Commission are professionals from many disciplines representing the Federal, state and regional agencies listed on the back cover, a Citizen Advisory Committee, and a Research/ Planning Advisory Committee composed of members of the region's scientific community.

> THE GOAL OF THE STUDY IS TO PRODUCE A PLAN OF ACTION BY THE SPRING OF 1975 WHICH BALANCES THE NEEDS TO PROTECT, CONSERVE AND WISELY DEVELOP THE SOUND AND ITS RELATED SHORELANDS AS A MAJOR ECONOMIC AND LIFE-ENRICHING RESOURCE FOR THE 12 MILLION PEOPLE WHO LIVE NEAR IT.

This planning report is one of a series. The first half of each report is problem-oriented. It summarizes demands placed upon the Sound and adjacent lands, their capacity to supply these demands, and present or expected needs to be met, if it is determined that supply should meet demand. The last half of each report is solution-oriented. It formulates tentative objectives and alternative measures for achieving the objectives. It evaluates the environmental, economic and social implications of each measure and formulates alternative plans. One plan is tentatively recommended. The planning reports are printed and distributed before the final version of main report. Therefore, final recommendations are to be found only in the main report, scheduled for publication in the Spring of 1975. Planning reports in this series include:

- Land Use
- Water Management
- Shoreline Appearance & Design
- Erosion and Sedimentation
- Flood Damage Reduction
- Recreation
- Fish and Wildlife
- Marine Transportation
- Minerals
- Power and the Environment

SUMMARY

PURPOSE OF THIS REPORT. To assemble information on damages sustained from tidal and riverine flooding and to recommend how these damages can be minimized in environmentally, economically and socially acceptable ways.

TIDAL FLOODING

HOW SIGNIFICANT IS TIDAL FLOODING TO THE PUBLIC?

Tidal floods produced by hurricanes and extratropical storms have caused loss of life, massive damage to public and private property, and possibly-significant ecological destruction---7 percent of the regional damage is in NewYork, mostly in Westchester---the remainder is in Connecticut---in 1938, 250 were killed and $125 million in damages were sustained in nearby Providence---public interest was high after the 1938 hurricane, was rekindled after the 1954 storm, and has waned in recent, calmer years---damages from a recurrence of either the 1938 or 1954 floods are estimated at $64 million---average annual tidal flood damages are estimated at $11 million in 1970 rising to $17 million in 1990 and $32 million in 2020---if no additional damage abatement measures are taken, these damages will aggregate about $1 billion over the next 50 years.

WHAT CONDITIONS ARE REQUIRED FOR MINIMAL FLOOD DAMAGE?

For a coastline to experience minimal damages, the following conditions are required: (1) benign forces of nature, especially few hurricanes and severe storms and "luck" in having them strike in favorable locations and circumstances (2) resistant, undeveloped coastal areas, and (3) foresight coupled with action.

HOW DOES THE SOUND MEASURE UP TO THESE REQUIREMENTS?

Overall, it measures up fairly well along the Long Island coast, poorly along the Connecticut coast---the forces of nature are fairly severe---hurricanes have hit in 1938, 1944, 1954, and 1961, severe storms in 1935, 1953, and 1968---those in 1938 and 1954 were storms of record---the water surface rose 6-10 feet above mean high water and much higher levels were reached because of wave heights and wave runup---coastal conditions are sensitive---the coastline is ecologically fragile---the Connecticut shore is highly developed, with low-lying cities on funnel-shaped estuaries which magnify storm surges---its narrow beaches with few dunes make poor buffers---fortunately, Long Island provides considerable protection to the western part of the Sound---on Long Island's north shore, high bluffs are exceptionally erodible but fairly well protected from direct storm forces---

WORK GROUP RECOMMENDATIONS

The Composite Plan is recommended --- its 11-point program is outlined below and is itemized in more detail in Section 11 --- it employs flood control structures (principally coastal) dikes and watershed reservoirs and 10 non-structural solutions --- the plan will cut aggregate flood losses over the next 50 years by one billion dollars --- it will cost $139 million, expressed as the present worth of all future investment, operating and maintenance costs --- 50-70 percent of the $72 million project costs are Federal --- most of the cost of the other measures fall directly upon the citizens of the region --- elements of the plan with the percentages of damage they are expected to reduce or account for are as follows:

1.	Provide flood control structures	36%
2.	Modify hurricanes	16%
3.	Regulate land use	10%
4.	Floodproof, voluntarily	6%
5.	Floodproof, involuntarily	6%
6.	Forecast, warn & evacuate	3%
7.	Educate the public	2%
8.	Apply other government programs	2%
9.	Accept some of the damage	19 %
10.	Qualify for flood insurance	-
11.	Assist in emergencies	-
		100%

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1.0 PURPOSE OF THIS REPORT

The purpose of this planning report is to assemble information on damages sustained from tidal and riverine flooding and to recommend how these damages can be minimized in environmentally, economically and socially acceptable ways.

To accomplish its purpose, the first half of this planning report is(1) problem-oriented. For both tidal flooding and riverine flooding, it --

- Examines how the public is affected,
- Outlines major conditions that must be met to lessen flood damage,
- Evaluates how the coastal and riverine areas around Long Island Sound measure up against these conditions, and
- Identifies major problems.

The second half of the planning report is solution-oriented. It --

- Offers objectives,
- Identifies alternative measures for achieving the objectives,
- Evaluates the alternatives,
- Formulates three alternative plans -- stressing environmental quality, economic development and a composite of the two.
- Offers tentative staff recommendations, and then adjusts these initial recommendations to accommodate multi-purpose considerations and public input.

TIDAL FLOODING

2.0 HOW IS THE PUBLIC AFFECTED BY TIDAL FLOODING?

2.1 Introduction

Storms are physical disturbances currently uncontrollable by man. They cause millions of dollars of property damage and loss of life. They also limit beach recreation, waterfront development, and wetland values.

The tidal flooding part of this report focuses on flooding directly influenced by the sea. Often these seaborne influences combine with other influences from inland and from the atmosphere to magnify tidal flooding and these instances are considered. Riverine flooding will be considered later.

1- Published as an "Interim Report" in October, 1973 in 1000 copies.

Hurricanes were first recorded in the early seventeenth century. The inundation levels they produced were apparently higher than those produced in the recent floods of 1938 and 1954, although these two floods caused the greatest damage.

2.2 Direct manifestations of public desires

Prior to the 1938 storm, people did little to protect themselves and their property. Most were unaware of the potentially powerful blows that nature could generate. Consequently, the majority of the populace was very indifferent to tidal flood protection.

The hurricane of 21 September 1938 caused tremendous damage to the northeastern United States. As a result, the government set in motion studies of the hardest hit areas and the ones with the greatest potential damages. Six hurricane protection projects studied by the Corps of Engineers were authorized. Two have been built and one is under design. The remainder were deauthorized, or became inactive. The high cost of structural methods has been rejected by the local communities, which by law must share in project costs. Apparently more in favor now are non-structural alternatives such as flood proofing and land use controls.

2.3 Indirect manifestations of public desires

Although tidal flood control projects are not currently popular, there is no doubt as to the great popularity of the resources, activities and facilities that are becoming increasingly desirable subject to tidal flood damage. Many miles of sandy beaches are extensively used during the summer. Most coves attract recreational boating. Residential development along the shore is intense.

The greatest impact of tidal flood damage is upon coastal property, especially in urban areas. Buildings, roads, bridges, boats and dock facilities can be damaged or destroyed. During storms, combined sewer systems discharge untreated wastes into nearby water bodies. In extreme cases, they could produce significant public health problems. Some of this damage is mitigated, however, by the greatly improved dilution and flushing characteristics associated with storms. Shipping channels can be filled with sediment and the ships themselves can be damaged in port along with extensive port facilities. Coastal airports can be inundated. Great storms can also have important effects on shallow water coastal ecosystems. A breached barrier beach or plugged inlet can drastically change the ecology of an entire lagoon and associated wetlands system. Storm induced sediment movements can have gross mixed effects.

2.4 Distribution and projection of damage

Table 1 records projected tidal flooding damages in 1970, 1990 and 2020 on an annual basis and for a recurrence of the 1938 hurricane. The estimates are conservative for two major reasons:

- They include only monetary damages to structures and their contents. They exclude erosion and sedimentation losses, which are covered in another planning report. They also exclude allowances for the loss of life, for human suffering, for the loss of business income during recovery, and for other social and environmental losses.[1]

- They modestly project increases in future damage. It is difficult to project these increases because of the uncertainty which surrounds the effectiveness of current local flood plain controls. It was conservatively assumed that if correst measures are maintained and no additional damage-reduction measures are initiated, losses will increase at about 40 percent of the rate of growth of personal income in the region.[2]

3.0 WHAT CONDITIONS ARE REQUIRED TO MINIMIZE THESE TIDAL FLOOD DAMAGES?

To minimize damages, the principal causes must be controlled. These are the forces of nature, the condition of the coastal area subjected to these forces, and the extent of human intervention.

---

[1] - For a listing of the many nonmonetary environmental, economic and social criteria related to flood damage reduction, see Appendix F.

[2] - According to the NAR study (17) based upon a detailed model study of the United States for the period 1929-1958, a 70 percent factor would have been more appropriate. A much lower percentage (40%) was selected for the LIS Study on the basis of two judgements: (1) constraints against flood plain development are somewhat tighter today than they were during the 1929-1958 period, and (2) in the interest of maintaining credibility, it is probably better to understate future damages than to risk exaggerating the need for action.

TABLE 1. ESTIMATED TIDAL FLOODING DAMAGES
(in millions of 1970 dollars)

Subregion	Shore (Miles)	Average annual damages 1970	1990	2020	1938 Hurricane 1970	1990	2020
1 Southeastern, Ct.	154.1	2.51	4.02	7.53	30.0	48.0	90.0
2 Ct. River Estuary	63.0	.82	1.31	2.46	5.4	8.6	16.2
3 South Central Ct.	86.3	1.73	2.77	5.19	5.5	8.8	16.5
4 Greater Bridgeport Valley	45.3	2.88	4.60	8.64	6.0	9.6	18.0
5 Southwestern, Ct.	77.5	2.36	3.78	7.08	13.0	20.8	39.0
6 Westchester, Bronx Nassau	114.2	.32	.51	.96	3.2	5.1	9.6
7 West Suffolk	84.7	.11	.18	.33	1.1	1.7	3.3
8 Central Suffolk	38.0	.02	.03	.06	.2	.4	.7
9 East Suffolk	18.0	*	*	*	*	*	*
TOTAL	681.1	10.75	17.20	32.25	64.4	103.0	193.3

*Minor.

1970 damages are a compilation of individual community data contained in Appendix C. Damages for 1990 and 2020 are based on projection factors discussed in the text.

3.1 Forces of nature

For minimal tidal flooding damage, a coastal community must experience no hurricanes and its storms must be of low intensity, brief duration and low frequency. The tidal range must also be small. Over the short term, the community must also be lucky -- lucky to escape significant storms, lucky to have those that do occur strike on the preferred side of the community (see quadrant effect below), and lucky to have the storms strike during low tide and before inland flood run-off reaches the coastal river mouth. Over the long range, however, luck is not really a factor. Although the frequency and magnitude of the largest possible flood will always remain somewhat in doubt, the state of the art is sufficiently well advanced for each coastal community to know rather clearly just what it should expect and about how often it will occur.

3.2 Coastline conditions

For minimum tidal flooding damage, a coastal community must be lightly developed, must be high above the sea, must have a favorable coastal configuration (not at the end of a funnel shaped embankment or at a river mouth), must have a favorable orientation opposite a short fetch of shallow water, and must have a coastline that offers maximum resilience to the erosion producing forces that always accompany tidal flooding.

One important consequence of orientation is a quadrant effect caused by the circular motion of storm winds. This effect is exemplified by the hurricane. In the northern hemisphere, because of the rotation of the earth, winds blow counterclockwise, as seen from above, about a low pressure center. Thus, the winds in one quadrant of a hurricane crossing the coast will be away from the coast producing relatively little damage and those in the opposite quadrant will pile up water against the shore. This pile up can cause extraordinary littoral movement.

Funnel shaped estuaries with wide openings and narrow necks are at a particular disadvantage. A large mass of water can easily enter the estuary with great momentum. As the estuary narrows, the only direction this water can move is upward.

When the funnel effect is combined with the quadrant wind effect, with high spring tide and with torrential inland runoff in urban areas, conditions become especially severe.

3.3 Human intervention

For minimum tidal flooding damage, a coastal community must be aware of the threat, have planned to minimize its effects and have executed the plans. It must have considered and implemented appropriate structural measures such as raising the elevations and flattening the profiles of beaches; restoring, improving, and constructing dunes; constructing barriers, gates, dikes, seawalls, and breakwaters; flood proofing its exposed facilities; and controlling inland run-off. The community must also have considered and implemented a variety of appropriate flood plain management techniques to minimize exposure. And it must have considered and implemented programs such as early warning, emergency evacuation, and flood insurance to minimize the significance of the damage that does occur. More briefly, the community must have developed a coherent multifaceted plan and must execute it.

4.0 WHAT ARE THE CONDITIONS IN THE REGION?

4.1 Forces of nature

This section describes very briefly storm and tidal data for the Sound and observed high water levels produced by their combined effects and other factors.

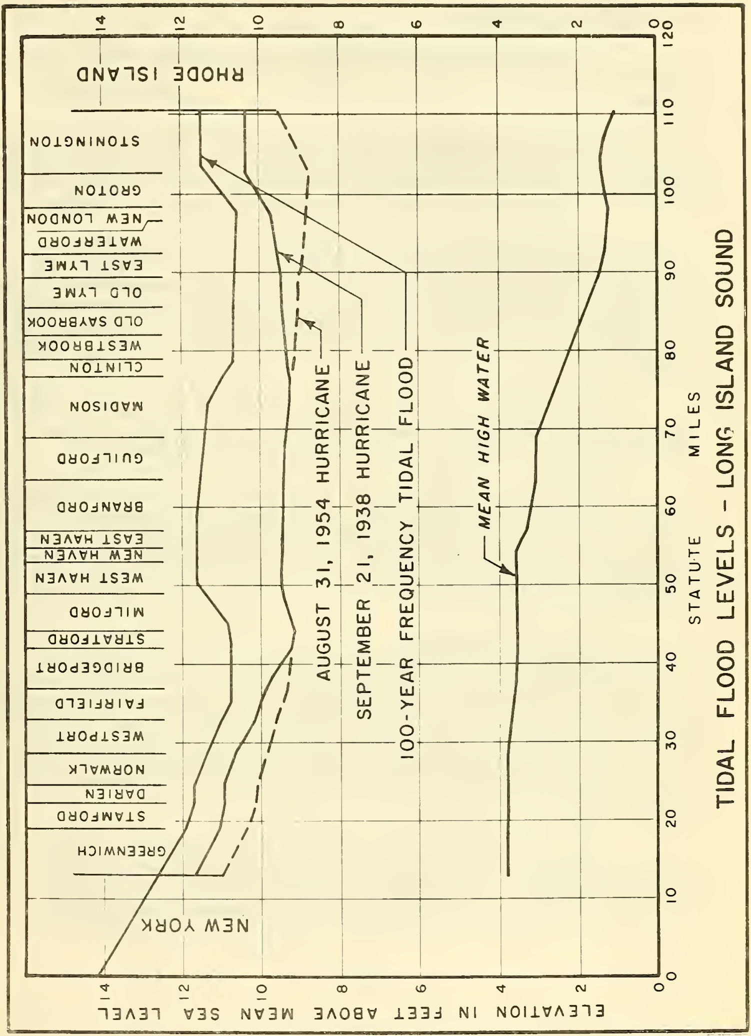
Hurricanes and major storms frequent the area. This century, hurricanes have hit Long Island Sound in 1938, 1944, 1954, 1960, and 1961. Storms accompanied by significant tidal flooding also occurred in 1935, 1950, 1953, and 1968. The storm of record is the 1938 hurricane. For much of the coast, however, the hurricane of 1954 produced water levels of equal height.

In Long Island Sound, the height of each tide varies during the lunar month and the time interval for a complete tidal cycle averages about 12 hours and 25 minutes. The mean tide range in the Sound varies from 1.9 feet at Montauk Harbor at the eastern end to 7.4 feet at Huntington, New York and Greenwich, Connecticut near the western end. Spring tides occur at times of new and full moons when the tidal forces of the moon and sun act in the same direction. The spring tide ranges from 2.3 feet at Montauk Harbor to 8.5 feet at Huntington.

The determination of design water elevations under storm and hurricane conditions represents a most complex problem involving the interaction between wind and water, particularly in shallow depths. In most coastal locations, the wind causes an increase or decrease in water level above or below those caused by tidal action. This change in surface elevation results from tangential stresses at the water surface between wind and water and, to a lesser degree, from differences in atmospheric pressure over the water surface.

Figure 1 depicts hurricane flood levels along the Connecticut shore. The elevations are stillwater elevations. Along the immediate shoreline, wave run up ---which is influenced by wind direction, local orientation and local coastal configuration --- will be considerably higher than still water elevations. Note how the hurricane flood levels rise on the western end of the Sound in the same way that storm surges rise near the head of a funnel-shaped estuary. The rise continues into New York State (not shown in Figure 1). The 1938 hurricane for example, produced a tidal level of 13.8 feet at City Island in the Bronx.

Also displayed on Figure 1 for the purpose of comparison is an estimate of the mean high water level. This is the mean of all high waters (about two daily) produced by the combined forces of tide and wind observed over a considerable period of time.



TIDAL FLOOD LEVELS - LONG ISLAND SOUND

FIGURE 1

4.2 Coastline conditions.

This section describes the study area generally in terms of the coastline conditions that affect the economic and social costs of tidal flood damage.

Level of urbanization. The shoreline of the Sound is intensely developed, particularly toward its western end and especially in the major cities. The hurricane of 1938 killed 250 people in Providence (only a little outside the study area) and caused damages there of about $125 million.

Height above sea level. The inner parts of the major cities of New Haven, Bridgeport, Greenwich, and New London are at low elevation. Any coastal community can observe how its critical elevations compare with those shown in Figure 1 plus the additional elevation added by wave heights and runup effects. On the Long Island shoreline, most development is high above mean sea level with the result that tidal flooding is a minor problem there.

Configuration. All of the major cities on the Connecticut shore are located on funnel-shaped embankments and river mouths, circumstances which greatly increase their vulnerability to tidal inundation.

Orientation. The coastline of western and central Long Island Sound receives substantial protection, Long Island's south shore absorbs the ocean surges, and for most storms the island reduces the fetch and consequently the amount of wave buildup. The eastern end of the Sound however, does not enjoy these advantages. It is open to the ocean and is opposite deeper water.

Stability of the coastline. Some portions of the mainland shore are rocky, especially in Westchester and adjacent parts of Connecticut. For the most part, however, the Connecticut shoreline is beach. In most places, the beach is narrow and steep with no significant dunes behind it. This type of shoreline presents little obstacle to tidal flooding. The least resistant shoreline in the Sound runs along all of Suffolk County and most of Nassau County. Here high water and wave action falling on very narrow beaches wear away the base of high bluffs and cause major slides of unconsolidated glacial materials.

Combined effects. The above brief description should be adequate to give each coastal community a general grasp of how severe its tidal flood threat could be. Some of the effects are offsetting. For example, although the western part of the Sound is more favorably situated with respect to the factors listed under "orientation", it is less favorably situated with respect to tidal ranges mentioned earlier. To quantify each effect and calculate the net effect, an engineering study would be required.

4.3 Human intervention

After reviewing the current level of public awareness, this section describes past efforts to reduce tidal flood damage. The early approaches were primarily structural, but non-structural measures are gaining emphasis. Since the threat is relatively minor for most of the Long Island side, the comments pertain principally to Connecticut.

Awareness. Because it has been some time since the last significant tidal flooding, the man on the street is undoubtedly little aware of or concerned about the threat. Observation of the rapid intense buildup of shoreline facilities confirms this assumption. The State and most coastal municipal governments, however, have previously become aware of the degree of threat in their localities through participation in past Corps of Engineer surveys. As is always the case, however, an extended period without major storms has dropped the issue to a low priority.

Structural plans. Most of the attention to date has been given to planning tidal flood control structures. In response to a Congressional directive, the U. S. Army Corps of Engineers completed study of high damage areas of the New England and New York coastlines in 1955 (1).[1] This study resulted in the authorization, design or favorable recommendation of flood reduction projects at six localities. A hurricane barrier at Stamford and hurricane protection at Pawcatuck have been constructed and a project at New London is active. Because of inadequate public support a project at Stratford is inactive and the projects at Mystic and Westport have been deauthorized.[2]

Following the 1955 hurricane, the Corps of Engineers prepared a series of studies (listed in Appendix A); and the principles of hurricane tidal flood protection and related water resource developments were applied to all cities and towns of Connecticut, and to Westchester and Suffolk Counties of New York, which were subject to tidal flooding. The North Shore of Nassau County, Long Island, New York, was recently covered by a Tidal Flood Plain Information report, dated June 1972. The Bronx and Queens Counties are now under study by the New York District, Corps of Engineers as part of a multi-year project.

---

[1] - Underlined numerals in parentheses are references in Appendix A.

[2] - A more detailed tabulation of these and other projects will be given later in Section 9.

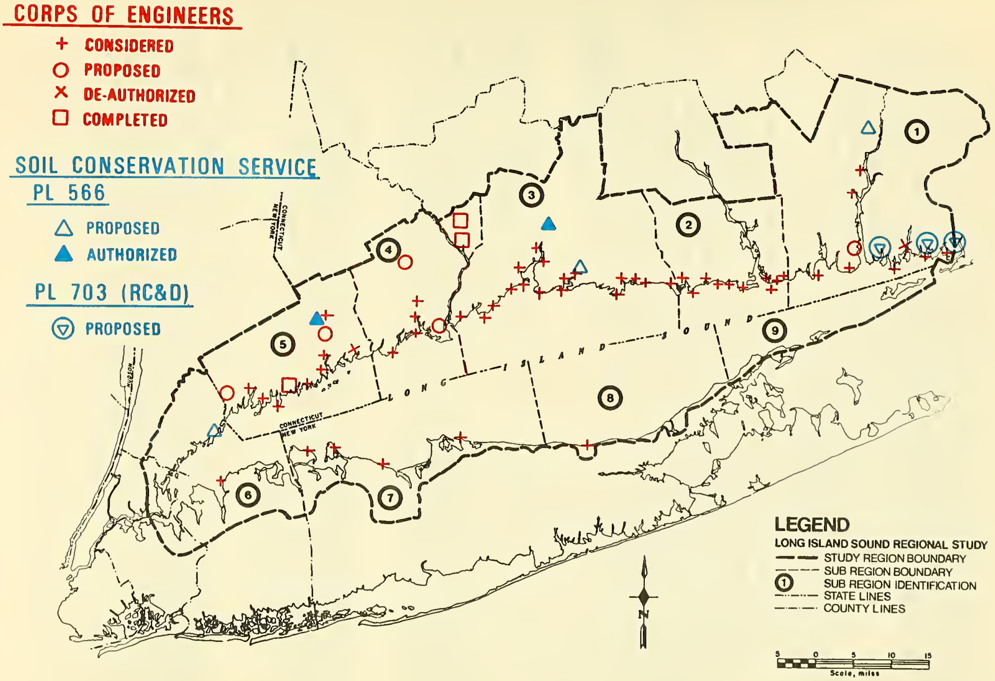
As a result of the above Corps studies, general plans, based upon sound coastal engineering practices, were developed for each community that had areas of concentrated damages. These general plans are summarized by community in Appendix C to serve as a guide to future integrated public and private development. It was found in each case that, under present economic conditions and current requirements for federal participation (thirty percent local contribution, seventy percent federal and also a benefits-cost ratio equal to or greater than one), additional hurricane protection would not be warranted for various reasons, including the wide distribution and scattered nature of damages, the cost of construction and the reluctance of local interests to participate in the cost of protective measures at this time. Hurricane protection plans were evaluated both alone and as multiple-purpose projects in conjunction with completed or recommended beach erosion control measures.

Figure 2 depicts the location and status of federal projects and studies in the region. The Soil Conservation Service projects will be discussed in Section 6 and a detailed tabulation of major projects will be given later in Section 9. Inspection of the figure clearly brings out the very high proportion of Corps studies which concluded that no protection was justified. Thus the responsibility falls to subfederal levels of government to achieve damage reduction through non-structural means.

Some of the cost distribution problems of structural methods are overcome by flood proofing, strengthening or relocating structures. Here the costs are directly borne by the beneficiaries. Following hurricane Carol in 1954, a number of homes and other buildings within the flood zone were relocated or raised to place their first floor level above the height of expected future hurricane tides.

Non-structural plans. Partially because of high tangible costs associated with structural methods and environmental opposition to most structural solutions, emphasis is shifting to non-structural plans. They are relatively new. Instead of attempting to mitigate the forces of nature, they attempt to restrict usage of damage prone areas so that the losses will be less. Considerable damage reduction can be achieved this way, but it always has to be measured against the value of opportunities foregone and new values created. Both are frequently neglected in the analysis.

Flood plain management techniques have been developed over the past decade for riverine flood plains, but similar management techniques for tidal flood areas along the coast have received little attention. Much more work needs to be done to apply them to specific localities. Flood plain zoning should prohibit development on low lying areas. However,



LOCATION OF FEDERAL FLOOD CONTROL PROJECTS AND STUDIES

FIGURE 2

variances are being granted and man continues to trespass on the land that belongs periodically to the ocean. Some communities have proposed flood plain zoning, but they have been voted down by people who are either unconcerned or who own property in these zoning areas. The apathy of the many remaining communities has caused concern among state officials. In Connecticut, Public Act 75-570, signed into law on June 11, 1973 provides for expansion of Environmental Protection to include areas subject to tidal flooding. Some proponents of flood plain management advocate a state law forcing a community to adopt flood plain zoning or have these flood prone areas come under state control.

Flood insurance has aroused interest in many of the cities and towns. This is apparent from the increasing list of communities eligible for flood insurance under the emergency program. Some communities, however, have balked at the requirements for eligibility in the regular program and thus will be dropped. By allowing commercial and industrial development to expand at an uncontrolled rate, the community is jeopardizing the lives and property of the owners and employees in the area and also creating a hardship on the community and state. Appendix E provides a community-by-community summary of the status of flood plain management and flood insurance eligibility in the region, as prepared by the Department of Housing and Urban Development (HUD).

All of the towns along the Sound have programs in effect that provide for the evacuation of residents from flooded areas and their accommodation during the emergency period. These evacuation programs, together with the hurricane warning services now provided by the National Weather Service, are essential supplements to other protection plans for the area. An example of mobilization measures that can be taken is contained in a report entitled "A Model Hurricane Plan for a Coast Community"(3).

Government programs. Federal programs are cited throughout this report. The flood control activities of the Corps of Engineers have been summarized above and the programs of the Soil Conservation Service will be discussed in Section 6. Both agencies also have flood plain management assistance programs.

Connecticut's flood control program consists of both federal, state, and local cooperative construction programs and state and local cooperative programs to prevent further development in flood prone areas. Through the joint efforts of the major governmental agencies at various levels, flood prevention programs in Connecticut have relied basically on a systems approach in that the programs, whether by construction or regulatory protective devices, are considered on a watershed or river basin basis.

New York State also has a significant flood control program, but it will not be discussed further because the threat of tidal (or riverine) flood damage on the north shore of Long Island is comparatively minor. Westchester County has enacted legislation to control encroachment on the natural stream channel.

4.4 Federal studies by subregion

The following discussion provides information on federal studies and projects to supplement the detailed community-by-community tabulations of tidal flood damages depicted on Figure 2 and itemized in Appendix C:

Subregion 1. The main areas of flooding are the Stonington-Groton area, covered by House Document 411 (4) (Mystic) and the New London area, House Document 478 (5). The Mystic project design was approximately 35 percent complete when the project was classified as inactive on 21 November 1967 because of a lack of local support. It has since been de-authorized. The New London project's submission date to the Office of the Chief of Engineers for the post authorization change report is scheduled for late fall of 1974.

Subregion 2. In this subregion, no special projects were authorized by Congress. However, the four coastal towns of Old Lyme, Old Saybrook, Westbrook, and Clinton all experienced major damage in certain areas.

Subregion 3. No federal projects are pending in this subregion. There were major damages, however, in every one of the seven coastal communities: Madison, Guilford, Branford, East Haven, New Haven, West Haven, and Milford.

Subregion 4. Of the three coastal communities in Subregion 4, two received federal aid. The recommended project in House Document No. 292 (6) for Stratford was in advance engineering and design in January 1972, when the Stratford Town Council passed a resolution withdrawing previous assurances. All design was suspended immediately. The project was officially reclassified to inactive category the following month.

Fairfield was studied in House Document No. 600 covering 3.4 miles. The benefits were large and the costs low, but public support was lacking. Therefore the project was marked unfavorable. The remaining community in Subregion 4, Bridgeport, had three areas with major damage: Seaside Park, Tongue Point, and Pequonnock River. Two local protection projects have recently been completed - Ansonia-Derby and Derby.

Subregion 5. The major damage areas in this subregion are Westport and Stamford. One mile of shoreline in the Compo Brook area of Westport (7) is studied in House Document No. 412. In Stamford (8), the completed project (House Document No. 210) covers two miles of the 11 mile total. Other major areas of damage are Norwalk, Greenwich and parts of Westport.

Subregion 6. In this subregion, the only area in which damage was significant or concentrated in City Island and vicinity in the Bronx. The highest tide recorded in this area was at elevation 13.8 feet msl. This area is exposed to wave attacks during hurricanes and extra-tropical storms, resulting in damages to shorefront properties, including marinas, houses, boatyards, and boats. Low areas are obviously inundated.

Subregion 7. No federal projects are authorized in this subregion.

Subregion 8. In the town of Southold, the major area of damage is Hashamomuck Beach. The beach with its residential and commercial developments in low-lying areas, was one of the hardest hit areas during the August 31, 1954 hurricane. Fifty acres of fertile land were inundated when home-made dikes failed. In Riverhead, a mile section in Wading River was severely eroded and houses were washed into the meadow. Homes 0.5 miles back from the shore were flooded with 5 to 6 feet of water.

Subregion 9. At Orient Point, vessels and dolphins were smashed during the 1954 hurricane. On Fishers Island, low-lying Elizabeth Airfield is vulnerable. Other vulnerable areas are Silver Eel Cove, Hay Harbor, and West Harbor. All have had much development in the past two decades.

RIVERINE FLOODING

5.0 HOW IS THE PUBLIC AFFECTED BY RIVERINE FLOODING?

In 1955, Connecticut experienced three major floods as the result of tropical hurricanes. The floods resulted in the loss of over ninety lives and property worth millions of dollars. More recently, flooding in the Mississippi River Valley, in Virginia, and elsewhere, has created widespread concern over flooding. The problem of flooding is not new. The occurrence of a catastrophic flood creates a greater public awareness of the problem, but it soon seems all but forgotten. Nationally, floods cost us about $1 billion every year and the losses are expected to be five times as great by 2020. According to Soil Conservation Service estimates, for every $6 of potential flood damages prevented by new controls, the building of new businesses, homes, etc., on "protected" flood plains results in $5 damages -- if flood plain management techniques are not also applied to the protected area.

Originally, flood plains were the most convenient locations for towns because of readily available water for transportation and power. As towns expanded, flood plains provided flat, easily accessible areas for homes, factories, and roads. Now, because of the increasing demand for land as home and factory sites and the lack of public information and foresight, we are continuing to develop flood plain areas. Thus, a problem which was always significant and never solved is becoming steadily worse and more urgent.

5.1 Distribution and projection of damage

The present and projected estimated annual riverine flooding damages are shown on Table 2. For a more specific breakdown of damages by river basin, see Appendix D. The floodwater damages were developed from a study of existing Public Law 566 watershed projects. Flood prone areas were delineated on USGS 1:24,000 topographic maps. A drainage area versus flood depth graph was used to locate flood lines. Completed flood hazard studies were used when available. The numbers of various kinds of properties within the flood plain were determined by a 50 percent field count and a 50 percent map count. The damages included only monetary damages to structures and their contents and crop losses. They excluded erosion and sedimentation losses which are covered in another planning report. They also excluded allowances for the loss of life, for human suffering, for the loss of business income during the recovery, and for other social and environmental losses.[1] Floodwater damages for each watershed were estimated for the 100-year frequency event. The average annual damages were estimated to be 7 percent of the 100-year frequency event. Projections for the years 1990 and 2020 are based on material developed for the North Atlantic Regional Study (9). In this study, future potential damages were determined by weighting agricultural and non-agricultural projections in proportion to present damages. The projections assume people will continue to use the flood plain but less than in the past.[2] Table 2 indicates the tremendous amount of potential flood damages which can be expected to occur in the region if no additional flood damage reduction measures are initiated.

The damages could be particularly high in Subregions 3 and 5. This reflects the possibility of high potential floodwater damages in the Byram River, the Rippowan River, the Noroton River, the Norwalk River, and in the Quinnipiac River. Appendix D contains a more specific list by river basin.

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[1] - For a listing of the many nonmonetary environmental, economic and social criteria related to flood damage reduction, see Appendix F.

[2] - See Section 2.4 for further detail on the method for projecting future damages.

About 2 percent of the total LISS riverine flood damage occurs in New York State, essentially all in Westchester County on the Mamoroneck and Sheldrake Rivers and other small streams.

TABLE 2. ESTIMATED ANNUAL RIVERINE FLOODING DAMAGES
(in millions of 1970 dollars)

Sub-region	Streams with Major Damage	Flood Plain Acres	Damages 1970	1990	2020
1	Thames River, Shetucket River	16,480	0.78	1.25	2.36
2	Chester Creek	5,100	0.32	0.51	.96
3	Quinnipiac River	14,150	1.78	2.85	5.32
4	Ash Creek, Pequonnock River	3,770	1.16	1.86	3.48
5	Rippowan, Noroton & Norwalk	6,330	1.85	2.96	5.55
6	Mamaroneck & Sheldrake Rivers	720	0.30	0.48	0.90
Total		46,550	6.19	9.91	18.57

5.2 Conditions affecting riverine flooding

The usual cause of floods is excessive rainfall. Floods have also occurred due to melting snow, high tide, ice blockage and overtopping or failure of reservoir dams with the sudden release of large volumes of water. Storms in the region are of three general types: (1) storms of tropical origin (hurricanes); (2) northeasters; and (3) thunder storms.

Development and urbanization are the chief contributions to local flooding. Pavement, roofs, compacted soil, and storm sewers all increase the amount of runoff and speed of water to a stream. Encroachment upon the flood plain by buildings and land fills constricts the flow of water, thus increasing floodwater depths. The dynamic combination of natural storms and man-made conditions results in even greater flood losses.

6.0 WHAT HAS BEEN DONE TO MINIMIZE RIVERINE FLOOD DAMAGES?

Structural and nonstructural. Human actions to lessen riverine flood damages can be considered -- as they were earlier for tidal flooding --- to be a mix of complementary structural and non-structural measures. Essentially all of the one-page discussion of non-structural approaches given earlier in Section 4.3 applies with equal force to riverine flooding. Later in Sections 9 and 10, both types of solutions will be examined, advantages and disadvantages will be weighed and conclusions and recommendations will be developed. For now, some examples will be given in the context of existing government programs and related projects.

Government programs. Riverine flood damages are being lessened through three programs administered by the Soil Conservation Service for the United States Department of Agriculture. They are the Soil Conservation (PL-46), the Food and Agriculture (PL-703), and the Watershed Protection and Flood Prevention (PL-566) programs.

PL-46 provides technical assistance to local units of government, developers, and individuals. Soil Conservation Service also assists with land treatment measures and in land use planning and installation of conservation measures. Over 500 individual property owners in the study region are using this assistance.

A Resource, Conservation and Development project for eastern Connecticut, sponsored by the Connecticut Department of Environmental Protection and administered by a local committee, is presently planning flood prevention measures for Old Mystic Seaport, Bluff Point and Stonington.

Through PL-566, SCS provides technical and financial assistance to local sponsors for the planning and installation of flood prevention projects. Also under PL-566, Flood Hazard Analyses are made for local committees, providing them the data necessary to implement flood plain zoning. Wharton Brook in Wallingford is the only Flood Hazard Analysis made within the LISS area. One PL-566 project has been completed at Spaulding Pond Brook in Subregion 1. The status of all other projects is summarized later in Section 9.

In addition to the SCS programs, the Corps of Engineers has three programs that relate to assistance for local areas, rather than to basin or regional needs. These programs, which are listed below, do not require specific authorization by Congress. They are classified as Small Projects. Section 205 of the 1948 Flood Control Act, as amended has a Federal cost limit of $1 million and may include dikes, channel work, and pumping stations to prevent flooding. Section 208 of the 1954 Flood Control Act has a Federal cost limit of $100,000 and involves snagging and clearing to prevent flooding. Section 14 of the 1946 Flood Control Act, as amended has a Federal cost limit of $50,000 and provides bank protection against streambank erosion for public works such as roads, bridges, sewage treatment plants, and other items under this category. All these programs are subject to economic justification, local assurances, local maintenance of the project, and local assumption of those costs not borne by the Federal government.

Investigations of Small Projects in the LIS Study region were undertaken during Fiscal 1972 and 1973 in the following Connecticut localities:

Five Mile River, Darien
Horseneck Brook, Greenwich
Five Mile River, New Canaan
Quinnipiac River, North Haven
Housatonic River, Shelton
Rippowam River, Stamford
Quinnipiac River, Wallingford

Flood plain information studies made in the region include Corps studies on the Hutchinson, Blindbrook, Mamaroneck and Sheldrake basins in Westchester County in 1964 - 1967.

The Connecticut Department of Environmental Protection has established encroachment lines on several rivers as a step toward total flood plain management. Listed below are the towns within the study region and associated rivers that have these encroachment lines.

- Greenwich - Byram River
- Stamford - Rippowan and Noroton Rivers
- Norwalk, Wilton - Norwalk River
- Bridgeport, Fairfield - Rooster River
- Seymour, Ansonia, Derby - Naugatuck River
- New Haven - West River
- North haven, Wallingford - Quinnipiac River
- Sprague - Shetucket River
- Norwich - Quinnebaug River

Appendix E indicates the status of other flood plain management programs by town in the study area. Note, for example, that most communities in Westchester have become eligible for flood insurance; none have yet passed a flood plain ordinance.

7.0 TENTATIVE PLANNING OBJECTIVES

The goal of the Long Island Sound Regional Study is to produce a plan of action by January, 1975, which balances the needs to protect, conserve and wisely develop the Sound and its related shorelands as a major economic and life-enriching resource for the 12 million people who live near it. This goal can be attained by reflecting society's informed preferences for attainment of two broad study objectives, as established by the U.S. Water Resources Council (11):

- Environmental Quality (EQ). This objective seeks to enhance the quality of the environment through the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems.
- Economic Development [1](ED). This objective seeks to increase the value of the output of goods and services and improve economic efficiency.

For this particular report on Flood Damage Reduction, the tentative planning objective is:

> To minimize tidal and riverine flood damages (reported in Tables 1 and 2) in environmentally, economically and socially acceptable ways.

To meet this objective, alternatives are formulated and evaluated in terms of environmental, economic and social criteria. Three plans are developed. One emphasizes environmental quality. One emphasizes economic efficiency. The third reflects a composite of the first two plus additional social considerations.

After multipurpose plan formulation and public scrutiny, the tentative planning objective will be either confirmed or modified.

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1 - Referred to as "National Economic Development" by the Water Resources Council. Unless specifically stated otherwise, economic development as construed herein is also equivalent to the WRC concept of "regional development". See Footnote 11 in Appendix F for further discussion.

8.0 ALTERNATIVES

To meet the objective -- of minimizing damages -- five broad alternative approaches are available: (1) reduce the extent and frequency of the flooding, (2) minimize the damages that will still occur, (3) reduce the damage potential by limiting development in locations susceptible to flooding, (4) accept the remaining damage as being beyond practicable reduction, and (5) mitigate the suffering from the damage accepted.

Within these broad alternatives, a large number of specific alternative measures are listed in Table 3. Measures 1-c, 1-d and 1-e in the table are implemented by large specific projects. The remaining alternatives are essentially policy measures applicable almost everywhere. Most entries are self explanatory. Description and discussion of each are deferred briefly to the next section so that they can be interpreted along with the evaluation.

9.0 EVALUATION OF ALTERNATIVE MEASURES

In Appendix F, the alternatives listed in Table 3 are condensed to 17 flood damage reduction measures. A total of 54 environmental, economic and social criteria are developed to reflect guidance contained in the Principles and Standards of the U.S. Water Resources Council, environmental impact statements and other sources. Each of the 17 measures is rated in terms of each of the 54 criteria. Footnotes describe terms, explain the basis for the evaluations and provide some additional references.

In this section, only the highlights of the evaluations will be described and broader perspectives will be suggested. Table 4 is a summary of the matrix in Appendix F.

9.1 Major environmental considerations

As reflected in Table 4, evaluation based upon environmental criteria is favorable in the case of land use regulation and governmental programs that minimize development in the flood plain, and in the case that accepts the damages. It is neutral in the case of measures that minimize flood damage, that accept the damage and that mitigate suffering. It is generally adverse to measures that reduce the flooding itself.

Of the many reasons that contribute to this general posture, the following three ecological premises are particularly significant:

TABLE 3. ALTERNATIVE FLOOD REDUCTION MEASURES

1. REDUCE THE FLOODING
    - a. Modify hurricanes
    - b. Control the land runoff
        - (1) By land treatment
        - (2) By conservation measures (e.g. wetlands)
    - c. Impound the flood waters (e.g. single & multipurpose reservoirs)
    - d. Improve the channel capacity
        - (1) By channel deepening, widening and realigning
        - (2) By removing natural and man-made obstacles
    - e. Confine the flow (e.g. dikes, flood walls and levees)

2. MINIMIZE DAMAGES FROM THE FLOODING
    - a. Flood proof--voluntarily
    - b. Flood proof--mandatorily
    - c. Forecast, warn and evacuate

3. CONTROL DEVELOPMENT IN THE FLOOD PLAIN
    - a. Public policy inducements
        - (1) Change current usage
            - (a) By multipurpose acquisition
            - (b) By compensable regulations
        - (2) Change future usage
            - (a) By educational policy
                - 1. Guidelines on priority uses of flood plains
                - 2. Flood plain delineation, mapping and description
                - 3. Warning signs
            - (b) By financial policy
                - 1. Current use tax
                - 2. Tax adjustments
                - 3. Graduated mortgage rates
            - (c) By application of other public programs
                - 1. Location of utilities, roads and other public services
                - 2. Land use policies
                    - a. Planned unit development and cluster zoning
                    - b. Density transfer
                    - c. Wetlands protection laws
                    - d. Open space goals
                    - e. Other developmental policies and programs
                - 3. Health regulations
    - b. Regulate land use
        - (1) By encroachment lines (including channel and harbor lines)
        - (2) By zoning
        - (3) By subdivision regulations
        - (4) By permits (zoning board of appeals) to (1), (2) and (3) above
        - (5) By acquiring development rights in conjunction with regulations
    - c. Directly acquire flood prone land
        - (1) By acquisition of development rights
        - (2) By acquisition with flood damage reduction as primary objective
        - (3) By permanent evacuation and urban renewal

4. ACCEPT THE DAMAGE

5. MITIGATE SUFFERING FROM DAMAGE ACCEPTED
    - a. Insure
        - (1) By voluntary subsidized programs (HUD)
            - (a) Emergency program
            - (b) Regular program
        - (2) By voluntary non-subsidized program (not feasible)
        - (3) By mandatory subsidized program
        - (4) By mandatory non-subsidized program
    - b. Assist in emergencies (rescue and aid)

TABLE 4. SUMMARY EVALUATION OF ALTERNATIVE MEASURES

Alternative flood damage reduction measures	Environmental Quality(EQ)	Economic Development (ED)	Social Well-being(SW)
REDUCE FLOODING	POOR	FAIR-GOOD	GOOD
Modify hurricanes	Poor	Good	Good
Control land runoff	Good	Fair	Good
Impound flood waters	Fair	Good	Good
Improve channel capacity	Poor	Fair	Good
Confine flood waters	Poor	Good	Good
MINIMIZE DAMAGES FROM FLOODING	FAIR	GOOD	GOOD
Flood proof--voluntarily	Fair	Good	Good
Flood proof--mandatorily	Fair	Fair	Fair
Forecast, warn, evacuate	Fair	Good	Good
CONTROL FLOOD PLAIN DEVELOPMENT	FAIR-GOOD	POOR-FAIR	MIXED
Relocate--multipurpose	Fair	Poor	Good
Regulate land use	Good	Poor	Fair
Educate	Fair	Poor	Fair
Control finance	Fair	Poor	Poor
Apply other gov't programs	Good	Fair	Good
ACCEPT THE DAMAGES	GOOD	POOR	POOR
MITIGATE SUFFERING FROM DAMAGE	FAIR	POOR	GOOD
Use federal insurance	Fair	Poor	Good
Use commercial insurance	Fair	Poor	Poor
Assist in emergencies	Fair	Good	Good

The belief that flooding, particularly extreme flooding causes desirable disturbances in the ecosystem.

This belief is held by some biologists who have studied flooding. It is tersely stated in the following quotation from Stickel (12):

> "Abnormally high, random and rare floods are most important as they set back ecological succession (albeit temporarily) during its inevitable march toward theclimax stage. It is these set backs which do two things: (1) maintain the diversity and high level productivity of riverine systems; and (2) sort out (via genetic bottlenecks and similar evolutionary related phenomena) those populations of species of plants and animals best adapted for survival in an environment (i.e., flowing-aquatic) which scientists informed in the area will admit is naturally never completely controllable. To overly restrict this ecological-evolutionary potential (by eliminating the rare, high floods) could result in as undiversified and unproductive an environment as would be found in and along channelized river."

This belief is also related to the deposit of needed nutrients by periodic flooding of ecosystems. It is well known that mineral substances beneficial to plant life are transported by river and tidal flood plain waters and deposited on flood plains and tidal marshes. Without this periodic replenishment, the floodland ecosystems would depreciate in viability due to gradual removal of minerals through leaching.

There is a need, both to define what is meant by "abnormally high, random and rare floods", and also to define what is meant by "overly restrict". Nevertheless, the above concern was given due consideration in the development of programs to alleviate flood problems.

The belief that flood plains have much higher ecological value than most other land forms and that man's activities there usually diminish these values.

Few would dispute the first part of this premise - nature, as well as man appears to prefer flood plains. Few would also deny the second part of this premise. Some will also recognize, however, that the degree of interference with living resources ranges from very low (e.g., canoeing) to medium (e. g., farming) to intense (e. g., urban development). To provide perspective it is useful to define how widespread the interference actually is(e. g., the proportion of a basin's flood plain that is used for urban development and for ecological purposes).

The belief that many damage abatement measures in themselves, cause adverse ecological disturbances.

Few would dispute this premise when applied to the immediate locale of a structure - the dam site, straightened channel or floodwall. When one considers the net, long term (i.e., once the immediate effects fade away), widespread (i.e., basinwide) effects on total systems (i.e., over-all biotic communities) this premise usually still pertains. As emphasized in the first premise favoring floods, all major natural "calamities" are not necessarily bad. All major man-induced perturbations may not necessarily be bad for long-term ecological development, although individual instances of harmful (and beneficial) ecological effects of every significant change and non-change can always be found.

9.2 Major economic considerations

As reflected in Table 4, economic criteria favor cost efficient measures such as (potential) weather modification, impoundments, dikes and some forms of floodproofing. They are neutral with respect to marginally-efficient measures for reducing flooding. They are adverse to accepting economically reducible flood damage, to measures that significantly restrict major economic uses of the flood plain and to flood insurance.

Of the many reasons that contribute to this general posture, the following three premises are particularly significant:

The belief that the expected benefits ("direct and indirect") of a proposed action ought to exceed the expected costs ("direct and indirect") of that action.

Most would accept this premise, but great differences arise over indirect costs and benefits. Economic interests frequently suspect the "soft" adjectival rating given to noneconomic values (e.g., overworked use of words like valuable, priceless, unique and fragile). On the other hand, environmentalists believe that the economist may be overemphasizing the accounting tool (dollars) to the detriment of their preferred end (harmony with nature). Given these differences, full agreement here probably cannot be reached. The economic developer will continue to value the benefits/cost ratio as the major rational, objective way of reaching significant conclusions. The environmentalist will continue to reject it unless it points to conclusions he has reached through other means.

From the point of view of the flood plain occupant, highly subsidized government flood insurance is economically desirable because the occupant pays only about 40 percent of the value of the flood risk. However, from the perspective of national economic efficienty (the viewpoint adopted in this section), the program is uneconomical because it requires the total expenditure (government plus occupant) of about $2.50 for every dollar of flood damage compensated.

The belief that the full economic costs of some land use management measures can exceed the cost of the flood damages they are designed to reduce

The principal costs often neglected here are the locational benefits foregone and the added infrastructure costs, such as roads and utilities to serve the new locations. A few economic activities such as ports must be located adjacent to the water edge and some others such as power plants and other water-using industries can practicably be set back only a little distance. Probably more important than industrial proximity to water, however, is commerical proximity to the heart of towns and cities. The very high unit costs of downtown acreage attests to its locational advantages for commerical purposes. The loss of this acreage must be taken into account. Otherwise, well-meaning efforts to bar downtown from development so as to reduce flood damages might well cost the displaced activity and society much more than the flood losses abated. Many towns are located at the junction of several highways which come together to cross a bridge. Rail and bus routes then converge in the same locale. In the interest of more efficient transportation, energy savings and general commercial intercourse, it is efficient for commercial activity to build up at this junction. If the activity is forced inland, it can mean less business, and to the region and nation it will mean more energy and money spent to provide the added roads and services to a less advantageous location.

There are many exceptions, however, to the above general pattern of a stable urban center. In some communities in the study region, downtown is dying and is characterized by obsolete mills, marginal businesses, ratty structures, deteriorated housing, vacant lots, and abandoned structures and railroad stations. In such locations, a well-conceived urban renewal program may conclude that the locational benefits forgone in gradually phasing out development in the flood-prone sectors of the city are indeed be trivial.

The belief that government controls in general and land use controls in particular unduly restrict the entrepreneurial initiative that is the cornerstone of a vital economy.

Objections to government controls are deepseated. Objections to land use controls go back to the English common law -- sic utere tuo ut alienum[1] non laedas. Objections to government control of economic processes were articulated in Adam Smith's laissez faire. With the increasing complexity of society, certain controls have come to be accepted as necessary. Nevertheless, the strong tendency persists to place the burden of the proof squarely on the proposers of new controls.

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1 - Use your own property in such a manner as not to injure that of another.

9.3 Major considerations of social well-being

As reflected in Table 4, evaluation based upon social criteria is favorable for all measures that reduces flooding, for voluntary flood proofing, for a few land use measures, for subsidized flood insurance, and for emergency assistance. It is neutral in the case of most flood plain development measures. It is unfavorable in the case of mandatory flood proofing, financial policies such as tax adjustments and mortgage penalties, and commercial (non-subsidized) insurance. Some measures present special legal, institutional and political difficulties because of their tendency to induce a high level of judicial involvement, to cause administrative difficulties in implementation, or to require new legislation. Prominent among these measures are hurricane modification, changing land use patterns and certain financial policies.

Considerations of social equity generally favor in principle the sharing of costs fully among the beneficiaries in proportion to their benefits. This goal has been long advocated by economists and recently by the National Water Commission under the principle of user charges. The principal is violated usually to simplify administration in most federal programs--especially those in which benefits are widespread--including water resources programs and especially flood control programs. Under many structural solutions, the public bears most of the costs and the individual flood plain occupants generally enjoy windfall benefits. Under many non-structural solutions, on the other hand, society loads much more than the fair share of the costs on the occupant, who must bear most of the costs of opportunities foregone. Largely for these reasons, those outside the flood plain can be expected to prefer non-structural solutions as much as those inside the flood plain are apt to prefer structural measures.

The problem of achieving equitable, administratable cost sharing for federal water resources programs is currently under review at the national level. It seems best for this study to advocate its solution at that level, where all the factors can be weighed.

9.4 Measures to reduce flooding.

This group of measures can reduce flood damages to both existing and future development.[1]

Modify hurricanes. Current cloud-seeding techniques have a high probability of reducing peak hurricane wind velocities by about 15 percent. A velocity decrease of this magnitude would diminish the force of the wind by about 30 percent. Wind force affects storm surges. The most likely reduction in damages caused by winds and floods has been estimated generally of about 30 percent (18). Seeding of hurricanes is not expected to reduce their total energy, but to change its form. Thus while peak winds near the center diminish, the area covered by more moderate winds may increase. It is unlikely that total precipitation will be diminished, but there appears to be about one chance in three that within the next several decades man may learn how to alter the path of hurricanes by a few degrees (19). Even that small a change would be significant in moving these disturbances away from the Long Island region and out to sea, considering the long distance they travel from their origin to reach the Sound.

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[1] - A more detailed description and commentary on some of the measures address in Sections 9.4 through 9.8 herein can be found in forthcoming reports of the Connecticut River Basin Program, administered by the NERBC.

Modifying hurricanes in such ways would greatly reduce flood losses in the region. It would also significantly reduce erosion, sedimentation and water quality problems; promote job and economic base stability; and reduce a threat to life, health and safety in the Long Island Sound Region.

The effect would be greater along the coast than inland. Since the most severe tidal flooding usually occurs during hurricanes, reducing this threat would reduce tidal flood losses greatly, in the vicinity of 33 percent.[1] Inland, however, in a region of small streams such as the study regions, the major damage is caused by flash floods produced by local thunder showers. Modifying hurricanes, therefore, would have much less effect on small riverine flood damages, reducing them by about 10 percent.(1)

Objections to hurricane modification would most likely be based upon ecological, climatological, legal and institutional concerns. As stated earlier, major floods are believed by most biologists to be ecologically beneficial over the long run. Climatologists will want to be assured that hurricane modification will not significantly alter long term heat transfer between the tropics, and polar regions. Significant legal and institutional problems will be encountered because every change in a great storm will undoubtedly harm someone. But every failure to exercise a capability to make such changes may also harm many more. These are the types of unresolved problems, probably more than the technical ones, that may keep currently available techniques from being used for some time (19). It is assumed herein, however, because of the outstanding benefits which could result from hurricane modification, that research into the application problems will be pressed and that the difficulties will be resolved by the turn of the century, if not earlier.

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[1] Estimates on the effectiveness of hurricane modification in reducing tidal flood losses have been based on personal communication with Dr. Cecil Gentry (19).

Control of sediment and surface water run-off. Land treatment measures are designed to reduce erosion, to reduce water and sediment run-off and to protect soil and water quality. These measures modify floods primarily by increasing water infiltration, slowing surface water run-off, and temporary storage in small ponds or sediment traps. The Federal program is carried out by the U. S. Conservation Service through local soil and water conservation districts.

Land treatment measures vary with their setting. The chief land treatment measures on farmland are tree planting, use of cover crops, contour farming, grass waterways, minimum tillage, pasture and hay planting, terracing, diversions and ponds. The principal land treatment measures on urbanizing land are temporary and permanent grass seeding, sodding, mulching, grade stabilization structures, diversions, and sediment basins. Land treatment on forest land consists of revegetation of critical sediment producing areas, reduction in fire damage and use of above applicable conservation practices. These measures help limit the loss from flooding and can reduce the amount of sediment transported by floodwaters.

About the only limitation to these measures is their voluntary irregular application. Their purpose is to minimize erosion and sedimentation, as well as to delay run-offs. They are local high frequency floods.

Impound floodwaters. Flood control dams impound peak flows and release them when streamflow is low. Multi-purpose dams also meet other needs particularly recreation, water supply, and water quality through low-flow augmentation. Whether they improve or degrade the aesthetic and environmental quality of a river basin depends upon the observer's aesthetic values and the species and time frame envisioned. Generally, warm water species are benefited by the new lakes created particularly by multi-purpose dams. Cold water species experience a possibly detrimental change from a stream to a lake environment at the reservoir site, but apparently benefit downstream through the release of cold water from reservoir depths especially during periods of low flow. Anadromous species are critically affected by dams. Unless a (very costly) fish ladder is provided, they are cut off from their ancestral spawning grounds. The strongest objection to dams would probably come from ecologists who believe that major floods are ecologically beneficial over the long run and that structural measures in themselves are undesirable alterations to the ecological status quo.

Improve channel capacity. Enlarging, straightening and clearing channels of natural and man-made obstructions will lower flood stages in the immediate and upstream area. Objections may be on three grounds: (1) the damage abatement is only local, (2) the local aesthetic qualities of the natural stream are degraded, and (3) the local habitat, spawning and feeding capacities of the channelized stream may be significantly reduced. In non-urban areas, with care taken in the planning and design of the channels, existing wildlife habitat can sometimes be preserved or improved. In urban areas, the ecological impact of channels is minor if the biological quality of these areas is low at the outset of these projects.

Confine flood waters. Dikes and floodwalls with interior pumping stations provide direct protection at the point of need. They have little effect on the remainder of a river valley except immediately upstream where backwater effects are occasionally significant. Disadvantages include the possibility of overtopping, loss of access and the local loss of a view of the river or sea. Along the coast, gated barriers are sometimes employed to reduce tidal flood crests. The barriers also provide the advantages of breakwaters for small boats, but they can dampen the normal rise and fall of the tides with consequent adverse effects on wetland productivity. They can have an effect similar to that caused by a natural spit which tends to clog the mouth of a tidal channel that irrigated a wetland. In semi-eutrophic waters such as those in the western and central Sound, reduction in wetland productivity of organic materials may not necessarily be disadvantageous. The chemical content of organic material provided through wetland detritus may be more than amply provided by other means-in this area in which phyloplankton growth is so very prolific.[1]

Projects. The above descriptions were necessarily general. Most of the measures must be implemented in the form of projects. Projects are most applicable to protect high existing concentrations of floodprone property, or to protect sites for future development where the costs of foregoing flood plain usage are exceptionally high. Structural solutions can also provide some "land enhancement benefits", in that the protected land can be used more intensively than it was used before the protection. Land enhancement, however, must be controlled carefully. Without control, development could move further out onto the flood plain thereby increasing its flood exposure to equal or sometimes exceed what it was before the project. At worst, a project could lull the public into a false sense of security thereby increasing the flood risk. These observations point up the conclusion that all significant flood control projects ought to be supplemented with a land use program that reflects a studied tradeoff between potentially enhance of usage benefits and potentially increased flood damage exposure.

Table 5A describes 10 tidal flood projects. They are survivors from about 50 possible projects originally considered. Table 5B describes 13 riverine projects, 11 by SCS and 2 by the Corps. Figure 2 shows the location of all projects studied. SCS has also considered many more projects and presently has rejected all except those listed in the table.

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[1] - This observation should not be construed as an argument against wetland preservation. Productivity is only one of the many functions of wetlands listed in the planning report on fish and wildlife.

TABLE 5A. TIDAL FLOOD CONTROL PROJECTS

	PROJECTS	NEW LONDON *	MYSTIC	MONTVILLE	THAMESVILLE	GROTON Long Point	POINT O'WOOD	STRATFORD	BRIDGEPORT Seaside Park	BRIDGEPORT TONGUE PT.	BRIDGEPORT Pequonock Rvr	FAIRFIELD	WESTPORT
	SUBREGION	1	1	1	1	1	2	4	4	4	4	4	5
	PROJECT STATUS	active	deactivated	studied	studied	studied	studied	inactive	studied	studied	studied	unfav. report	inactive
	Type of area protected	comm. resid	resid. comm.	ind.	ind.	resid.	resid.	ind. res.	ind. res.	ind	ind.	res.	res.
	Type of Project	Dike pump	Dikes wall gated barrier	Dike, wall, pump	Dike wall, pump	Dike, barrier, beach fill	Dike sand fill	dike wall pumps ramps, gated barrier	dike wall, raised road	dike wall	dike wall pumps	dike sand fill	dike walls ramp
Criteria	Environmental:	fair	poor	fair	fair	poor	good	poor	fair	fair	fair	fair	fair
	Economic Cost $1,000 (present worth)	13900	8,900	1,000	2,900	2,700	420	23,600	2,800	1,700	4,300	2,600	600
	B/C	1.0	1.1	4.0	2.2	1.8	1.4	1.4	1.1	1.3	1.0	2.1	3.0
	Social	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	Public Acceptance	Fair	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor
	Agency	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE
	Cost Sharing (approx % federal)	70	70	70	70	70	70	70	70	70	70	70	70

ANNUAL BENEFITS (Damages Abated in $1,000)

		NEW LONDON *	MYSTIC	MONTVILLE	THAMESVILLE	GROTON Long Point	POINT O'WOOD	STRATFORD	BRIDGEPORT Seaside Park	BRIDGEPORT TONGUE PT.	BRIDGEPORT Pequonock Rvr	FAIRFIELD	WESTPORT
EQ	1990	-	-	301	450	-	30	-	-	-	-	400	134
Plan	2020	-	-	564	843	-	55	-	-	-	-	750	251
NED	1990	850	675	301	450	342	30	2,605	-	182	-	400	134
Plan	2020	1,596	1,266	564	843	642	55	4,880	-	341	-	750	251
COMPOSITE	1990	850	-	301	450	-	30	-	-	-	-	400	134
Plan	2020	1,596	1,266	564	843	-	55	4,880	-	-	-	750	251
RECOMMENDED PRIORITY		1	2	1	1	3	1	2	3	3	3	2	1

* Project cost estimate to be revised to reflect reformulated project.

1. Costs, benefits and benefit-cost ratios are all computed based upon uniformly updated damage surveys and project designs.
2. The process of fitting individual projects into the three plans involved tradeoffs between the environmental rating, the B/C ratio and public acceptance on the following basis:

EQ Plan
If environmental - good, adopt
If environmental = fair,
and acceptance=good, adopt
if B/C exceeds 1.0.
and acceptance fair, adopt
if B/C exceeds 1.4.
and acceptance - poor, adopt
only if B/C exceeds 1.9.
Reject all other cases.

ED Plan
If B/C exceeds 1.1, adopt
If B/C = 1.0 or 1.1,
and acceptance=good or
fair, adopt.
Reject all other cases.

Composite Plan
If included in both EQ
and ED, adopt
If included in EQ or ED,
and acceptance=good
or fair, adopt.
and acceptance = poor
adopt only if B/C
exceeds 1.9
Reject all other cases.

3. Exceptions to the above rules were the Mystic and Stratford projects. Each was rejected for 1990 because of apparent very strong public opposition, but proposed for 2020 when the need will be much greater.

TABLE 5B. RIVERINE FLOOD CONTROL PROJECTS

PROJECTS		Yantic River	Harbor Brook	Muddy River	West River (New Haven)	Neck River	Munger Brook	Farm River	Farm Brook	Quinnipiac River	Trumbull Lake	Norwalk River	Norwalk-Wilton	Blind Brook
Subregion		1	3	3	3	3	3	3	3	3	4	5	5	6
Project Status		active planning	inactive	potential	inactive	active planning	active planning	active planning	under construction	potential	inactive	active construction	studied	active planning
Type of area protected		agri., rec. urban	recreation urban	recreation urban	urban	urban	rural	urban	rec.	urban	commer ind. resid.	urban	residen. ind. comm	urban
Type of project		dam, land treatment channel	dam, channel, land treatment	land treatment chan., dam	land Treatment channel	dam land treatment	land treatment dam	dam channel, land treatment	dam land, treat. channels	dam channel land treatment	dam, multi purposes: *	land treatment channel dam	dikes, walls, chann	land treatment channel dam
Criteria	Environmental:	fair	fair	fair	fair	fair	fair	fair	fair	fair	good	fair	poor	good
	Economic Cost $1,000 (present worth)	7,300	1,950	825	3,000	100	300	1,000	1,600	5,000	11,900	5,200	5,700	4,000
	B/C	1.3	1.5	1.0	1.6	1.2	1.1	1.0	2.0	1.0	1.5	1.9	0.9	1.0
	Social	good	good	good	good	good	good	good	good	good	good	good	good	good
	Public Acceptance	good	fair	fair	fair	good	good	fair	good	fair	fair	good	poor	good
Agency		SCS	SCS	SCS	SCS	SCS	SCS	SCS	SCS	SCS	CE	SCS	CE	SCS
Cost sharing (approx % federal)		70	70	50	70	50	50	50	50	50	58	60	63	25
ANNUAL BENEFITS (DAMAGES ABATED IN $1,000's)														
EQ Plan	1990	630	200	-	330	8	22	-	240	-	1,220	690	-	270
	2020	1,180	370	-	620	15	41	-	440	-	1,980	1,300	-	500
NED Plan	1990	630	200	55	330	8	22	70	240	330	1,220	690	-	270
	2020	1,180	370	103	620	15	41	130	440	625	1,980	1,300	-	500
COMPOSITE Plan	1990	630	200	55	330	8	22	70	240	330	1,220	690	-	270
	2020	1,180	370	103	620	15	41	130	440	625	1,980	1,300	-	500
RECOMMENDED PRIORITY		1	1	2	1	1	1	1	1	2	1	1	3	1

*watersupply, waterquality, recreation

1 - For explanation of costs, benefits, B/C ratio and plan formulation process, see footnotes under Table 5A.

If all of the projects were to be provided, they would reduce tidal flood damage by about 46 percent and riverine flood damage by about 43 percent -- by $15 million and $8 million annually in 2020. For many environmental, economic and social reasons, however, not all of these projects can or should be provided. The line labled "Acceptance" in both tables reflects the apparent public attitude when these or similar projects were considered in the past.

The basis for placing individual projects in the environmental, economic or composite plans is explained below table 5A. Note that the major decision factors were the overall environmental rating, the B/C ratio, and the public acceptance. No one factor was completely dominant. For example, poor public acceptance could be offset by high environmental and economic ratings. Conversely, a good public acceptance would lower the required environmental and economic ratings. If poor public acceptance does not change, it will certainly defeat any project regardless of its other merits. However, the study team construed its responsibility to require it to offer the public its own tentative recommendation rather than to feed back only what is known to be popular at the time. It tried to think of the day after the storm as well as the many calm days between storms.

9.5 Measures to minimize damages from flooding

Even if the above measures to reduce flooding were fully applied, many areas would still be flooded occasionally. Furthermore, for a number of envionmental, economic and social reasons cited, it will not always be wise to apply these measures. In either case, measures are necessary to minimize damages from any flooding that does occur. These measures can reduce flood damages to either existing or future development; however, they are more efficiently applied during initial construction.

Voluntary floodproofing. Individual buildings and their contents can be floodproofed by structural changes and adjustments. Overall, this measure has a capability to abate about 10 percent of the damages.

Floodproofing has promise in one or more of the following situations:

- Where moderate flooding with low stage, low velocity and short duration is experienced. This situation fits most headwaters and the small watersheds draining directly into the Sound.

. Where other types of flood protection are not feasible.

. Where individuals desire to solve their flood problems without collective action.

. Where activities dependent on waterfront location need some degree of protection.

. Where a higher degree of protection is desired than that provided by other flood control methods.

Many types of floodproofing measures have been recognized and studied, particularly in Europe where most major cities are periodically flooded. Examples of floodproofing measures are seepage control, sewer adjustments, permanent closures, protected openings, protected interiors, watertight caps, underpinning, timber treatment, and location of major utilities and valuables above the ground floor.

Floodproofing has been a theoretical choice for a long time, but it has never been accepted as a prime flood loss management alternative - even in areas where it appeared to be economically feasible. Factors making the effectiveness of floodproofing programs difficult include: (1) complexity and changes in ownership, (2) structural limitations, (3) residual damages, (4) the lack of Federal assistance, and (5) the possibility of leading to catastrophic loss, particularly if improperly done; of discouraging a more effective flood control measure, of discouraging sound land-use planning; and of becoming contingent on flood warnings. To determine the feasibility, it is recommended a detailed study be made for relocating, demolishing, raising and/or floodproofing.

Mandatory floodproofing. Floodproofing can be made mandatory by incorporating its provisions strongly in building codes applicable to future construction and, with limitations, in housing codes requiring modification of existing structures. Over-all, mandatory floodproofing has a capability of abating an estimated 7 percent of the 1990 flood damages and about 10 percent by 2020.

Building codes or regulations set forth standards for the construction of structures for the purpose of protecting health, safety, and general welfare. The following illustrate the type of requirements that can be specified under building codes to reduce flood damage:

. Prevent flotation of buildings from their foundation by requiring proper anchorage.

. Establish basement elevations and minimum first floor elevations consistent with potential floods.

- Require structural strength to withstand water pressure or the high velocity of flowing water.

- Restrict the use of materials which deteriorate rapidly when exposed to water.

- Prohibit equipment such as chemical storage, boilers, or electrical equipment that might be hazardous to life when submerged.

Within limits, housing codes can require application of many flood-proofing techniques to existing development. They can require repair and modification of flood-damaged structures to assure the safety of continued occupancy. In extreme cases, zoning ordinances can require amortization of non-conforming flood plain uses.

A much more complete description of potential building and housing codes can be found in a recent Corps publication, Flood Proofing Regulations(13).

Forecast, warn and evacuate. Accurate forecasting of flood stages and a workable warning system can be a boon to the life, health and safety of flood plain occupants. It may also enable them to remove some valuable portable possessions and thus prevent much damage. Hurricanes announce their coming days in advance, but sudden thus-far unpredictable shifts in their paths can cause them to strike the coast in surprising locations. Had hurricane Carla not suddenly and unexplainably turned away from the Sound in 1972, it would probably have produced the flood of record throughout the LIS region. Most of the inland portion of the region is drained by small watersheds on rather hilly terrain. These watersheds are subject to flash flooding caused by intense brief local storms.

In these situations, the practical effectiveness of forecasting, warning and evacuation is minimal. According to Appendix F, improvements in system efficiency have a potential to reduce flood losses on the order of about 5 percent along the coast and about 3 percent along the small rivers and streams in the region.

9.6 Measures to control flood plain development

Measures considered thus far can be characterized as "keep the water away from man". The measures to control development in the flood plain considered below apply a different strategy--"keep man away from the water". These measures can significantly reduce damages to future development; but, except for the first measure, they will have little effect on existing development.

Figure 3 and Appendices C and D locate the areas where flood damage is most severe and consequently where non-structural measures would be most effective.

Acquisition and redevelopment. One way to reduce future flood damage is for government (primarily the state) to acquire the flood-prone land, relocate the damage-prone activities and facilities and replace them with damage-resistant public uses such as beaches, open space and urban renewal projects. Although this policy may be justified in some special situations, it does not stand up under scrutiny as a significant flood reduction measure in this region.

Beach acquisition provides a good example. If attended at the rate contemplated in the planning report on recreation, and if each user day is valued at $2.00, each mile of developed public beach will produce recreational benefits at the rate of about $3.2 million annually. If the beach costs an average of only a half million dollars a mile annually[1], the benefits to costs ratio of this public investment is exceptionally high--6.4!

To these recreational benefits should be added any reduction in flood damages created by the replacement of damage-prone facilities with relatively damage-free public beach facilities. These additional benefits have been estimated by coordination between the work groups on floods and recreation and are summarized in Table 6 for the nine sites where the concept was considered worthy of investigation. The table shows that, when considered exclusively as a flood damage reduction measure, the benefits are trivial at every site when compared to costs.

Flood damages are also related to beach acquisition policy in another way. Theoretically, the price of coastal property should not drop much after a storm because the probability of such events would have been factored into the price. In practice, however, prices will be sharply depressed after a great storm--perhaps to half their former value. If then the pressure of state buying is added to the buying of private developers searching for bargains, prices would stabilize somewhat higher, perhaps somewhere around two thirds of their pre-flood level. This stabilization would provide a partial measure of relief to distraught flood victims, and the state would acquire coastal property at greatly reduced cost.

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[1] - Estimated at $7 million acquisition cost amortized at 6 7/8 percent over 40 years, and assuming that beach development costs are offset by user charges.

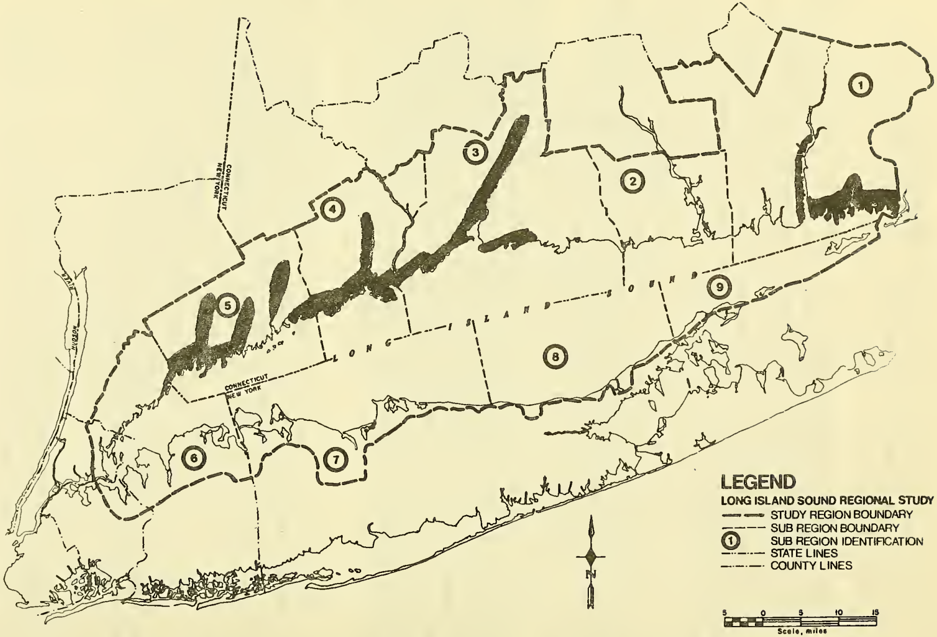

Figure 3. Priority locations for non-structural flood damage abatement measures. See Appendices C and D for details.

TABLE 6 ACQUISITION AND REDEVELOPMENT PROJECTS CONSIDERED FOR RECREATIONAL BEACHES

Subregion	Town	Beach[1]	Beach Length (mi)	Acquisition Cost ($million) Capital[2]	Acquisition Cost ($million) Annualized[3]	Maximum Annual Flood Damage Reduction[4]	Benefits to Cost Ratio
2	Old Lyme	Hawks' Nest	1.1	7.7	.55	.050	.091
2	Old Saybrook	Cornfield Point	1.3	9.1	.70	.015	.021
2	Clinton	Duck Island Rds.	1.5	10.5	.80	.010	.013
3	Madison	Circle Beach to E River Beach	1.0	7.0	.50	.070	.140
3	Madison	West Wharf	0.5	3.5	.25	.035	.140
3	East Haven	Shell Beach to Manaugin Beach	2.0	14.0	1.05	.260	.248
3	Milford	Milford Point to Myrtle Beach	2.9	20.3	1.50	.250	.167
3	Milford	Silver Beach & Fort Trumble Beach	1.0	7.0	.50	.086	.172
3	Milford	Bayview Beach & Point Beach	1.3	9.1	.70	.112	.160
4	Fairfield	Pine Creek Point	2.0	14.0	1.05	.138	.131
5	Westport	Owenoke	0.2	1.4	.15	.014	.093
5	Stamford	Shippan Point	0.2	1.4	.15	.016	.107
6	Bronx	Park of Edgewater	0.4	2.8	.20	nil	-
6	Oyster Bay	Ferry Beach	1.5	10.5	.80	nil	-
6	Oyster Bay	Oyster Bay	0.4	2.8	.20	nil	-
7	Huntington	Asharoken	1.7	11.9	.90	.003	.003
7	Brookhaven	West Meadow	1.1	7.7	.55	.002	.004
7	Brookhaven	Mt. Sinai	0.5	3.5	.25	.001	.004
8	Riverhead	Wading River	0.6	4.2	.30	nil	-
8	Riverhead	Baiting Hollow	1.3	9.1	.70	nil	-
8-9	Southold	Truman Beach	1.0	7.0	.50	nil	-
		Totals	23.5	164.5	12.30	1.064	.087

1. Includes all beaches considered by the recreation work group as potential public beaches and also flagged by the floods work group as possible redevelopment projects.

2. Estimated simply at $7 million a mile. For more detailed studies the cost for each reach would have to be individually determined.

3. Capitol costs amortized at 6-7/8 percent over 40 years.

4. This is all of the current 1970 damage expectancy. It is based primarily upon Appendix C. It assumes the ideal situation - that redevelopment as a public recreational beach would cut all future flood losses to zero. Values in this column will certainly rise in the future, but so will the cost, leaving the B/C ratio relatively unchanged.

While the state is waiting for the flood, however, the anticipated "savings" can disappear. For one thing, the basic property value will be rising steadily -- conservatively estimated at about 60 percent in 20 years in Tables 1 and 2 in constant dollars. Thus, if significant storms occurred at a frequency of about 20 years (close to actual experience), the benefits of waiting would be illusionary: flood -reduced prices 20 years from now would be about the same as current non-flood-reduced prices.

In general, the advantages of acquiring beaches at reduced prices after floods are more than offset by the constant long-term increase in land values--and especially by the very large recreational benefits foregone while waiting.

In summary, public beach acquisition should be timed to keep pace with growing recreational needs. To let floods significantly influence the policy is to let the tail wag the dog. It is also uneconomic, postpones social benefits and can encourage government procrastination.

For these reasons, acquisition-and-relocation is being dropped as a major flood damage reduction measure. Beach acquisition programs will be carefully evaluated in the recreation planning report, however, because that is where they primarily belong.

Regulation of land use. Encroachment lines, flood plain zoning, acquisition of development rights in conjunction with regulations, and subdivision regulations are all important land-use regulatory devices. Encroachment lines are designed to prohibit or limit, subject to permit, further development in the floodway. Along the floodway fringe where water depths and velocities are minimal, they usually do permit most uses, subject to adequate flood proofing. The floodway is delineated with varying degrees of sophistication depending primarily upon the developmental value of the land. Under the Connecticut program, encroachment lines must be delineated very precisely, much more precisely, for example, than is required under the National Flood Insurance Program. If requirements become too precise, they can make a program too expensive to implement.

Flood plain zoning is the most popular type of control on land development within flood plains. It designates the best uses of flood prone lands and establishes further requirements to make these uses more fully compatible with their location in the flood plain.

Under some land use regulations (e.g. Connecticut's Coastal Wetlands Law), if the courts find that the exercise of the law is a taking without adequate compensation, the state has several remaining options. It can drop the action. It can condemn the land and acquire it in fee simple. Or it can purchase development rights. The last option is presumably less expensive than acquisition in fee simple, yet it may still meet the state's objective of controlling future development. In practice, there is often very little difference in the cost of development rights and acquisition in fee simple.

Subdivision regulations are possibly the most effective means of controlling future growth in flood plains. The developer must comply with an often detailed list of requirements designed to meet rather precisely the community's reasonable flood plain objectives.

Overall, additional employment of land use regulatory measures can reduce 1990 flood losses by about 11 percent. Since regulations are most effective in minimizing future flood plain development, this capability could rise to about 16 percent by 2020. Of course, land use regulations serve many other pruposes other than flood damage abatement. They are also useful, for example, in recognizing and preserving archeological and historical sites and improving shoreline appearance. They generate a large volume of quasi-judicial activity on the part of the town boards that administer the programs. State enabling legislation and special ordinances are required to provide the necessary legal basis for the regulations. Appendix G contains two outlines of possible flood hazard zoning ordinances -- one for tidal and one for riverine flooding.

Educational policy. Educational policy includes the publication of guidelines on priority uses of flood plains; flood plain delineation, mapping and descriptions; and the posting of warning signs. These measures probably will have limited effect since most flood plain occupants, especially owners of the more valuable commercial-industrial facilities, already have a general awareness of the flood threat. Furthermore, flood plain delineation is expensive and slow since it must stand up to possible challenges in court. Its real value is as a foundation for land use measures and insurance. Its value as a deterrent (the value considered in this section) may not be worth much more than its cost. Overall, educational policy has an estimated capability of abating only 2-3 percent of future flood damages.

Financial policy. One way of controlling development in the flood plain is to impose differential property tax rates--lower for flood-compatible uses, higher for flood-prone uses. Adjustments in property tax rates can take several forms--(1) taxing on the basis of current use, not highest developable use; however, this approach encourages the retention of slums and derelict waterfront property for eventual speculative purposes; (2) deferred taxation, in which back taxes saved must be made up if the land usage is upgraded later, and (3) other methods whereby, in return for lower tax rates, an owner voluntarily binds himself not to increase the degree of development for a substantial specified period into the future.

Another possible financial tool is differential mortgage rates adopted voluntarily by commercial lenders. Theoretically, the flood risk is already factored into the property value, but other redundant tools can be used to emphasize the risk--collateral requirements can be more stringent, the down payment can be made higher, the interest rates can be raised, and the payment period can be curtailed.

All these tools will make the development of flood-prone property less attractive and thereby lessen future development and flood damages. The appropriateness of these policies as cost effective flood damage abatement measures may be questioned, however, since they all add artificial discounts to property values which presumably have already been influenced by the magnitude of their flood exposure. In cities especially, it is easy to recognize that susceptibility to occasional flooding may rank rather low among the many factors that determine a location's overall value to society.

For these reasons, and because public acceptance may be difficult to gain and administration rather complex, financial policies such as these may have little actual effect in abating future flood losses. The application of financial policies to force the use of federal flood insurance will be considered later under insurance.

Other government programs. Many other government programs can affect future flood plain development. Examples are coastal and inland wetland laws; the location of new roads, sewers and other development-inducing services well back from the flood plain; various land acquisition programs; and land use management programs with concepts such as planned unit development and density transfer. Furthermore, some federal programs might provide very limited funds to assist states and communities in carrying out several of the measures considered herein. Examples are the land and water conservation fund of the Department of the Interior; the revenue sharing program of the Department of the Treasury; and the urban renewal, model cities, open space, water and sewer, and neighborhood facilities program of the Department of Housing and Urban Development. None of these programs are flood damage reduction programs per se. Their capacity to abate flood damage is indirect and applies primarily to future rather than to existing development. Overall, their capacity to reduce the region's flood losses is probably on the order of 2-3 percent. In special circumstances, however, their role could be much more significant. For example, an urban renewal program could discourage the rebuilding of decaying developments located in the flood plain.

9.7 Accepting the damages.

For several major reasons, it is clear that no matter what measures are adopted and vigorously implemented, a substantial flood damage loss will always remain: (1) Many measures are ineffective with respect to existing development. (2) The value of flood-prone land and structures thereon keeps appreciating rapidly--strong testimony to its locational appeal. (3) With few exceptions, altruism can not be counted on to perpetuate advocated measures if the costs exceed the benefits. (4) Several of the abatement measures are strongly opposed by either environmental or developmental interests, thus making compromise solutions unlikely. (5) Some of the public have shown a lack of support for structural measures, particularly those identified with the Corps of Engineers. (6) Human inefficiencies, bureaucratic behavior and completely unanticipated acts of nature will continue to occur. These observations are presented here, not to set a note of pessimism, but to condition planners, readers and the affected public to the reality that there will always be a substantial residue of flood damage. This seemingly unnecessary reminder is mandated by the observation that many articulate critics have in the past--and will certainly in the future--discredit positive programs with the observation that much damage remains or that damages are even rising.

If nothing more is done, according to Tables 1 and 2, flood damages should conservatively triple by 2020, in constant 1970 dollars. Improvement on that level is the correct indicator of success.

9.8 Measures to ease suffering

For reasons given above, significant flood damages will remain, but insurance and emergency assistance can ease the suffering.

Insurance. Federally subsidized flood insurance is available to eligible communities under the National Flood Insurance Program, administered by the U.S. Department of Housing and Urban Development.

The program was established by the National Flood Insurance Act of 1968 (enacted as part of the Housing and Urban Development Act of 1968) to make specified amounts of flood insurance, previously unavailable from private insurers, available under federal agencies. The insurance covers the value of the damaged property, less depreciation.

Subsidized rates apply to existing construction and to all construction and substantial improvements begun before HUD finishes delineating the flood hazard area, a long and complex task. Thereafter, actuarial rates can be computed and will apply to all new starts. For $100 of average annual damage (the actuarial rate), the subsidized cost to the insured would typically be about $40 while the balance, including program administration, would typically be about $210. Thus the total cost for $100 of damage is about $250.

The program goes beyond financial relief in an effort to supplement other flood damage reduction measures. To become eligible for the initial "emergency program", community committments are modest. The community need only require building permits, establish needed anchorage requirements, review subdivision proposals, require public utilities to be appropriately elevated, and make suitable requirements for water supply and sanitary sewage systems. According to Appendix E as of 30 April 1974, of the 60 study region communities in Connecticut, 41 had qualified under the emergency program, 3 had applications pending and 16 had not applied. Of the 32 applicable communities in New York as of the same date, 23 had qualified under the emergency program, 2 under the regular program, and 7 had not applied.

To retain subsidized insurance coverage for its citizens after HUD has provided the flood hazard delineation information upon which actuarial rates can be computed, a community must qualify for the "regular program". To qualify a community must adopt a flood plain ordinance, give it precedence over other community ordinances in case of conflict, take into account the flood plain management programs of neighboring areas, require building permits and subdivision approvals and review them for adequacy in meeting a number of specified requirements, and make certain specified requirements of water and sanitary sewage systems. In addition, the community must require new residential construction to have the lowest floor, including basement, elevated to at least the level of the 100-year flood, must require new non-residential construction to be elevated or flood proffed up to that level, must designate certain floodway passages, must limit eapansions of existing non-conforming uses, and must regulate fill or encroachments within the need to carry the waters resulting from the 100-year flood. According to Appendix E, only two communities in the LIS region, the town of Brookhaven and the village of Asharoken, have qualified for the regular program. Both are on Long Island. However, 15 communities in the Connecticut part of the region, and 1 in New York part have flood plain ordinances.

The Flood Disaster Act of 1973 substantially expands the program. For example, the old ceiling on single family residences including contents was $22,500 for subsidized coverage and $45,000 for total coverage. The new Act doubles these figures. Erosion losses caused by abnormal water levels are now covered. The date after which new construction will be charged the actuarial (non-subsidized) rates is postponed until HUD publishes its initial "Flood Insurance Rate Map" for the community. Under the Act, the application of strong financial pressures will become mandatory and widespread. Every bank or other lending institution receiving any sort of federal assistance (almost all of them) will soon be required to deny building loans to anyone in the flood plain who does not subscribe to the insurance program--whether the fault be his or his community's failure to get itself qualified. Non-subscribers in flood-prone areas will also be denied disaster relief. Communities having flood-prone areas identified by HUD are required to participate in the flood insurance program by July 1, 1975, or be denied federally-related financing for projects that would be located in such areas. Lastly, the national limit for federal flood insurance coverage was raised from $6 billion to $10 billion.

The federal program thus contains many incentives to reduce future flood exposure. However, until and unless many more communities qualify under the regular program, it must be considered as primarily a social measure to spread flood losses among society as a whole.

Emergency assistance. Outside assistance to flood-stricken areas comes from all levels of government, from private and semi-public welfare agencies and from individual volunteers. Of these, the greatest assistance comes from the federal government primarily through its two principal[1] disaster assistance agencies, the Corps of Engineers and the Federal Disaster Assistance Administration, an arm of HUD. Although Corps obligations totaled $90 million nationally in Fiscal Year 1973, $12 million is a more typical figure. If this $12 million could be imagined to be used over a period of years in proportion to population (i. e. potential victims), the LIS Region's "share", with about 3 percent of the Nation's population, would be about $0.35 million. This is about 2 percent of the region's average annual damage.

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1 - Many other agencies, such as the Soil Conservation Services, are also authorized to provide emergency assistance.

10.0 FORMULATION AND EVALUATION OF ALTERNATIVE PLANS

The plan formulation process employed herein is founded completely upon material developed earlier in this report, especially (1) future damages projected for each subregion in Tables 1 and 2, (2) the evaluation matrix of individual measures presented in Appendix F and summarized in Table 4, (3) projects described in Tables 5a and 5b, and (4) the discussion of each measure in Section 9.

The building blocks are the individual measures and subregions. Note that the measures have not been intended to be mutually-exclusive alternatives. Indeed, it will often be best to apply all of them to different degrees to meet different circumstances. Each measure has been considered at the practicable limits of its capability. Its attributes and deficiencies have been displayed in terms of 54 criteria. Included among the criteria were interrelationships with other planning reports of the Long Island Sound Regional Study.

Plan formulation herein is in two steps. First one selects from the left column of the evaluation matrix the criteria judged to best represent a particular objective or point of view. The second step is to look horizontally across the line represented by each selected criterion and choose only the measures that are rated beneficial (+or++) or at least fair (o). The chosen measures thus represent the skeleton of a flood damage reduction plan tuned to the entry criteria.

As one example, a citizen could easily construct his own (say) unaccommodating environmental plan. To do this he could simply include only those measures rating Good environmentally in Tables 4 and 5, regardless of their economic or social ratings. To become even "purer" environmentally, he could consult the evaluation matrix in Appendix F and accept only those measures which ranked environmentally Good overall and had no environmentally negative scores among the individual environmental criteria.[1]

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[1] This process would produce a program that emphasized land use regulations and use of conservation-oriented government programs. Other abatement measures would be rejected. The resultant program would reduce flood damages by 13-19 percent, as estimated according to line 2a(1) of the evaluation matrix in Appendix F.

A very large number of alternative plans could be developed this way. A plan could be formulated, for example, to emphasize economic criteria in general, or more narrowly to include only B/C ratios above (say) 2.0, or to minimize potential legal-institutional problems, or to respond to any other set of selected criteria.

To maximize objectivity, then, this report would stop right here and throw the question to each reader: "Define your own values, then pick out your own plan."

But such a lack of focus would promote anarchy or apathy. Therefore, to stimulate desired public reaction, this study will adopt a limited number (two) of reasonably well-defined broad points of view. Chosen for this purpose are the environmental quality (EQ) and economic development (ED) objectives postulated earlier in Section 7.0. Each is more completely defined and illustrated by the Water Resources Council in its principles and standards (11), and the criteria in Appendix F were selected partly with this application in mind. After the EQ and ED plans were thus formulated, the study team formulated its own recommended composite plan to suggest how it believed differences between the EQ and ED plan might be resolved.

To facilitate the needed accomodation, neither the EQ Plan or the ED Plan is extreme. Each is unapologetically biased towards its own point of view, yet each explicitly accommodates to other points of view when the issue does not appear vital to its expressed bias.

The EQ Plan, for example was formulated (1) by accepting all measures scored as environmentally good in Table 4, (2) by rejecting all measures scored as environmentally poor, and (3) by deferring to economic and social criteria for all measures scored as environmentally fair. In the third case, if the measure were scored economically good it was accepted. and if economically poor, it was rejected; and if economically fair, it was referred to the social criteria. In the one case where environmental, economic and social criteria all rated fair, the measure was accepted.

The ED Plan was formulated in a similar way.

10.1 Environmental Quality Plan.

The EQ Plan emphasizes land use regulations, control of land runoff, and the use of conservation-oriented government programs. It accepts a few projects based upon individual evaluation in Tables 5a and 5b, voluntary and mandatory floodproofing, improved forecast-warning evacuation services and emergency assistance. It rejects hurricane modification, most projects including all that would reduce riverine flooding.

substantially or that would include barriers, multipurpose relocation, and educational and financial programs not geared to environmental ends. In general, it is attracted to the most effective ways of improving or maintaining the natural environment of flood plains.

The EQ Plan would cut annual tidal flood damages from $17 million [1] to $10 million in 1990 and from $31 million to $15 million in 2020, all at a total cost of about $57 million. It would also cut annual riverine flood damages from $10 million to $4 million in 1990 and from $19 million to $7 million in 2020. Details for each measure and each subregion are contained in Tables 7A and 7B.

10.2 Economic Development Plan

The ED Plan emphasizes most projects based upon their individual evaluation in Tables 5a and 5b, voluntary floodproofing, improved forecast-warning-evacuate services and emergency assistance. It accepts mandatory flood proofing and most other government programs related to flooding. It rejects a few projects, educational and financial policies, land use regulations, and flood insurance. In general it is attracted to the most cost effective ways of reducing flood damage.

The ED Plan would cut annual tidal flood damages from $17 million to $8 million in 1990 and from $31 million to $7 million in 2020, all at a total cost of about $78 million. It would also cut annual riverine flood damages from $10 million to $4 million in 1970 and from $19 million to $7 million in 2020. Details for each measure and each subregion are contained in Tables 8A and 8B.

10.3 Composite Plan

The Composite Plan emphasizes accommodation between the EQ and the ED Plans. Where these two plans agreed, their joint conclusion was embodied in the Composite Plan. In this way the following measures were incorporated: voluntary and involuntary floodproofing, improved forecast-warning-evacuation services, educational policy, and tie-in with other applicable government programs. Financial measures were dropped as they were excluded from both prior plans.

This left the following three remaining measures upon which the EQ and ED Plans split:

(1) Hurricane modification was favored by ED and rejected by EQ.

1-All total costs herein are expressed in terms of present worth. For example the $57 million cost cited above is that sum of money which if invested in 1970 at 6 7/8 percent interest would be just sufficient to meet all expected first costs and all operating and maintenance costs of the program to 2020.

TABLE 7A TIDAL FLOOD DAMAGE REDUCTION-- ENVIRONMENTAL PLAN

(in thousands of 1970 dollars)

Subregion, benefits and costs	REDUCE FLOODING					MINIMIZE DAMAGES			CONTROL FLOOD PLAIN DEVELOPMENT			ACCEPT THE DAMAGE	TOTAL
	Modify hurricanes	Control land runoff	Impound flood waters	Improve channel capacity	Confine flood waters	Flood proof- voluntary	Flood proof- involuntary	Forcast warn, evacuate	Regulate land use	Educate	Apply other Gov't programs		
B/C Ratio					2.5	2.0	1.3	over 10	1.1	1.2	1.6		
1 Benefits-1990					750	330	230	160	360	70	70	2,050	4,020
Benefits-2020					1,410	610	610	310	980	180	180	3,250	7,530
Costs[1]					3,900	2,060	2,250	200	4,830	750	520	-	14,510
2 Benefits-1990					30	130	90	60	140	30	30	800	1,310
Benefits-2020					60	240	240	120	380	70	70	1,280	2,460
Costs[1]					420	810	880	80	1,890	290	210	-	4,580
3 Benefits-1990					0	230	160	120	260	50	50	1,460	2,330
Benefits-2020					0	440	440	220	700	130	130	2,300	4,360
Costs[1]					0	1,470	1,610	140	3,450	540	370	-	7,580
4 Benefits-1990					400	420	290	210	460	80	80	2,660	4,600
Benefits-2020					750	790	790	390	1,260	240	240	4,180	8,640
Costs[1]					2,600	2,650	2,900	250	6,220	970	170	-	15,760
5 Benefits-1990					130	370	260	180	400	70	70	2,300	3,780
Benefits-2020					250	680	680	340	1,090	200	200	3,640	7,030
Costs[1]					600	2,300	2,520	220	5,410	840	580	-	12,470
6 Benefits-1990					0	50	40	30	60	10	10	310	510
Benefits-2020					0	100	100	50	160	30	30	490	960
Costs[1]					0	320	350	30	760	120	80	-	1,660
7, 8 & 9:													
Benefits-1990					0	20	10	10	20	0	0	150	210
Benefits-2020					0	40	40	20	60	10	10	210	390
Costs[1]					0	130	150	10	310	50	30	-	680
Total:													
Benefits-1990					1,310	1,550	1,080	770	1,700	310	310	9,730	16,760
Benefits-2020					2,470	2,900	2,900	1,450	4,630	860	860	15,350	31,420
Costs[1]					7,520	9,740	10,660	930	22,870	3,560	1,960	-	57,240

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1 - Expressed as present worth of all initial and future costs discounted to 1970 at 6 7/8 percent.

TABLE 7B RIVERINE FLOOD DAMAGE REDUCTION -- ENVIRONMENTAL PLAN
(in thousands of 1970 dollars)

Subregion, benefits and costs	REDUCE FLOODING					MINIMIZE DAMAGES			CONTROL FLOOD PLAIN DEVELOPMENT			ACCEPT THE DAMAGE	TOTAL
	Modify hurricanes	Control land runoff	Impound flood waters	Improve channel capacity	Confine flood waters	Flood proof-voluntary	Flood proof-involuntary	Forcast warn, evacuate	Regulate land use	Educate	Apply other Gov't programs		
B/C Ratio			1.5			2.0	1.3	over 10	1.1	1.2	1.6		
1 Benefits-1990			630			60	40	20	70	10	10	410	1,250
Benefits-2020			1,180			120	120	40	190	40	40	630	2,360
Costs[1]			7,300			390	430	20	920	140	100	-	9,300
2 Benefits-1990			0			50	40	20	60	10	10	320	510
Benefits-2020			0			100	100	30	160	30	30	510	960
Costs[1]			0			320	350	20	760	120	80	-	1,650
3 Benefits-1990			800			210	140	60	220	40	40	1,340	2,850
Benefits-2020			1,490			380	390	110	610	110	110	2,130	5,320
Costs[1]			6,950			1,290	1,410	80	3,030	470	330	-	13,560
4 Benefits-1990			1,220			60	40	20	70	10	10	430	1,860
Benefits-2020			1,980			150	150	50	250	50	50	800	3,480
Costs[1]			11,900			400	440	30	950	150	100	-	13,970
5 Benefits-1990			690			230	160	70	250	50	50	1,460	2,960
Benefits-2020			1,300			430	430	130	680	130	130	2,320	5,550
Costs[1]			5,200			1,430	1,570	90	3,360	520	360	-	12,530
6 Benefits-1990			270			20	10	10	20	0	0	150	480
Benefits-2020			500			40	40	10	60	10	10	230	900
Costs[1]			4,000			130	150	10	300	50	30	-	4,670
7, 8 & 9:													
Benefits-1990			0			0	0	0	0	0	0	0	0
Benefits-2020			0			0	0	0	0	0	0	0	0
Costs[1]			0			0	0	0	0	0	0	0	0
Total:													
Benefits-1990			3,610			630	430	200	690	120	120	4,110	9,910
Benefits-2020			6,450			1,220	1,220	370	1,950	370	370	6,620	18,570
Costs[1]			35,350			3,960	4,350	250	9,320	1,450	1,000	-	55,680

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[1] - Expressed as present worth of all initial and future costs discounted to 1970 at 6 7/8 percent.

TABLE 8A TIDAL FLOOD DAMAGE REDUCTION-- **ECONOMIC PLAN**

(in thousands of 1970 dollars)

Subregion, benefits and costs	REDUCE FLOODING					MINIMIZE DAMAGES			CONTROL FLOOD PLAIN DEVELOPMENT			ACCEPT THE DAMAGE	TOTAL
	Modify hurricanes	Control land runoff	Impound flood waters	Improve channel capacity	Confine flood waters	Flood proof- voluntary	Flood proof- involuntary	Forcast warn, evacuate	Regulate land use	Educate	Apply other gov't programs		
B/C Ratio	over 10				1.6	2.0	1.3	over 10	-	1.2	1.6		
1 Benefits-1990	0				2,620	140	100	70	-	30	30	1,030	4,020
Benefits-2020	870				4,910	260	260	130	-	80	80	940	7,530
Costs[1]	80				29,400	880	970	80	-	320	220	-	31,950
2 Benefits-1990	0				30	130	90	60	-	30	30	940	1,310
Benefits-2020	790'				60	240	240	120	-	70	70	870	2,460
Costs[1]	30				420	810	880	80	-	290	210	-	2,770
3 Benefits-1990	0				0	220	160	110	-	40	40	1,650	2,220
Benefits-2020	1,380				0	420	420	210	-	120	120	1,480	4,150
Costs[1]	130				0	1,390	1,530	130	-	510	360	-	4,050
4 Benefits-1990	0				3 ,190	140	100	70	-	30	30	1,040	4,600
Benefits-2020	880				5,970	270	270	130	-	80	80	960	8,640
Costs[1]	80				27,900	890	970	80	-	320	230	-	30,470
5 Benefits-1990	0				130	370	260	180	-	70	70	2,730	3,780
Benefits-2020	2,250				250	680	680	340	-	200	200	2,480	7,080
Costs[1]	220				600	2,300	3,520	220	-	840	580	-	8,280
6 Benefits-1990	0				0	50	40	30	-	10	10	370	510
Benefits-2020	320				0	100	100	50	-	30	30	330	960
Costs[1]	30				0	320	350	30	-	120	80	-	930
7, 8 & 9:													
Benefits-1990	0				0	20	10	10		0	0	170	210
Benefits-2020	130				0	40	40	20	-	10	10	140	390
Costs[1]	10				0	130	150	10	-	50	30	-	380
Total:													
Benefits-1990	0				5,970	1,070	760	530	-	210	210	7,900	16,650
Benefits-2020	6,620				11,190	2,010	2,010	1,000	-	590	590	7,200	31,210
Costs[1]	630				58,320	6,720	8,370	630	-	2,450	1, 710	-	77,830

1 - Expressed as present worth of all initial and future costs discounted to 1970 at 6 7/8 percent.

TABLE 8B RIVERINE FLOOD DAMAGE REDUCTION -- ECONOMIC PLAN
(in thousands of 1970 dollars)

Subregion, benefits and costs		REDUCE FLOODING	MINIMIZE DAMAGES			CONTROL FLOOD PLAIN DEVELOPMENT			ACCEPT THE DAMAGE	TOTAL
	Modify hurricanes	Control land runoff / Impound flood waters / Improve channel capacity / Confine flood waters	Flood proof- voluntary	Flood proof- involuntary	Forcast warn, evacuate	Regulate land use	Educate	Apply other Gov't programs		
B/C Ratio	over 10	1.4	2.0	1.3	over 10	-	1.2	1.6		
1 Benefits-1990	0	630	60	40	20	-	10	10	480	1,250
Benefits-2020	120	1,180	120	120	40	-	40	40	700	2,360
Costs[1]	10	7,300	390	430	20	-	140	100	-	8,390
2 Benefits-1990	0	0	50	40	20	-	10	10	380	510
Benefits-2020	100	0	100	100	30	-	30	30	570	960
Costs[1]	10	0	320	350	20	-	120	80	-	900
3 Benefits-1990	0	1,260	160	110	50	-	30	30	1,210	2,850
Benefits-2020	300	2,340	300	300	90	-	90	90	1,810	5,320
Costs[1]	30	13,780	1,000	1,100	60	-	370	250	-	16,590
4 Benefits-1990	0	1,220	60	40	20	-	10	10	500	1,860
Benefits-2020	150	1,980	150	150	50	-	50	50	900	3,480
Costs[1]	10	11,900	400	440	30	-	150	100	-	13,030
5 Benefits-1990	0	690	230	160	70	-	50	50	1,710	2,960
Benefits-2020	430	1,300	430	430	130	-	130	130	2,570	5,550
Costs[1]	50	5,200	1,430	1,570	90	-	520	360	-	9,220
6 Benefits-1990	0	270	20	10	10	-	0	0	170	480
Benefits-2020	40	500	40	40	10	-	10	10	250	900
Costs[1]	0	4,000	130	150	10	-	50	30	-	4,370
7, 8 & 9:										
Benefits-1990	0	0	0	0	0	-	0	0	0	0
Benefits-2020	0	0	0	0	0	-	0	0	0	0
Costs[1]	0	0	0	0	0	-	0	0	0	0
Total:										
Benefits-1990	0	4,070	580	400	190	-	110	110	4,450	9,910
Benefits-2020	1,140	7,300	1,140	1,140	350	-	350	350	6,800	18,570
Costs[1]	110	42,180	3,670	4,040	230	-	1,350	920	-	52,500

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[1] - Expressed as present worth of all initial and future costs discounted to 1970 at 6 7/8 percent.

Here the Composite Plan sided primarily with the ED Plan. In so doing, it reflected faith that the previously described environmental and legal questions can be resolved. However, it respected their significance by advocating intensive research now and by postponing major application of these techniques until they are indeed resolved, probably not before 1990. Sometime after that date, this measure could become the single most significant technique for abating long range tidal flood losses.

(2) Structures are sometimes the most controversial of all of the flood damage abatement measures. For that reason, they will be given some extra attention in this section on tradeoffs between EQ and ED recommendations.

The footnote to Table 5 has explained how the study team went about weighing the often conflicting demands of environmental quality, economic efficiency and public attitudes.

Of the 10 tidal projects costing $58 million--all Corps projects--that merited serious consideration, the EQ Plan included 5 costing $7.5 million, the ED Plan included 10 costing $58 million, and the Composite Plan accepted 8 costing $54 million. In addition, the Composite Plan recommended that two of the three most costly (and most beneficial) projects be deferred until the 1990-2020 time frame. These were the projects at Stratford and Mystic.

How this compromise came about was through a very difficult quarter-billion dollar tradeoff in which environmental factors and apparent public attitudes played the major role. As can be observed in Figure 4 the major difference between structures in the EQ Plan and structures in the ED Plan is in projects containing barriers. The ED Plan would spare residents and businesses in the threatened areas--Mystic, Groton Long Point, and Stratford -- an estimated $215 million in damages over the next 50 years. But the ED Plan would also partially block some channels thereby subjecting any wetlands inside the barriers to some reductions in the range of the tides that flush them daily. The effect on wetlands of reductions that turned out to be significant would probably be adverse, but the magnitude of these adverse effects is not easily quantified. The EQ Plan, by rejecting the barriers, would insure that the tides remained unchanged. It would also accept the $215 million damages.

In weighing the tradeoff, the study team noted that all four of these projects have failed to gain public support when aired in the past. Presumably, the affected public prefers to accept the $215 million damage. Therefore, the study team dropped two of the projects entirely and deferred two others--Mystic and Stratford--to 2020. In recommending delay in these two projects, the study team is actually proposing that the future decide. If the value of the exposed property continues to rise rapidly and if future storms cause the expected damage, the projectsmay become desirable. If not, they should be dropped.

For riverine flooding, of the 12 riverine flood control projects costing $50 million that merited serious consideration, the EQ Plan included 9 costing $35 million. The ED and the Composite Plan each included 12 costing $42 million. The difference was for three small SCS projects of marginal economic justification and of minor environmental consequence. All but one of the riverine projects are sponsored by SCS. Only one Corps project, at Trumbull Lake, survived.

In formulating all three plans, if a project were rejected, the non-structural measures were applied to minimize the damage that otherwise would be sustained. For the areas protected by tidal projects, particularly, the effectiveness of the non-structural devices is low. Tidal projects usually protect very concentrated existing development of high value exposed to easily forseeable severe damage. These areas usually have high locational value making the benefits foregone by their evacuation very high. Land use measures are not very useful in reducing damage to existing development, relocation costs would be very high, and the Stratford and Mystic areas especially are not particularly attractive for acqusition and conversion into mass regional recreation beaches. Flood proofing and improved forecast-warning-evacuation services would help reduce some of the damage. Easily the most beneficial future measure to the exposed communities, other than structural protection, is hurricane modification, but that solution will probably not be available for several decades, until potential environmental and legal problems are resolved.

(3) Land use regulation was favored by EQ and rejected by ED. Here the Composite Plan sided with the EQ Plan because this is a significant damage reduction measure particularly for reducing damages in the 1990-2020 time frames. It also seems to enjoy a wide base of support, especially from government, academic and environmental sectors.

TABLE 9A TIDAL FLOOD DAMAGE REDUCTION-- COMPOSITE PLAN

(in thousands of 1970 dollars)

Subregion, benefits and costs	REDUCE FLOODING					MINIMIZE DAMAGES			CONTROL FLOOD PLAIN DEVELOPMENT			ACCEPT THE DAMAGE	TOTAL
	Modify hurricanes	Control land runoff	Impound flood waters	Improve channel capacity	Confine flood waters	Flood proof-voluntary	Flood proof-involuntary	Forcast warn, evacuate	Regulate land use	Educate	Apply other gov't programs		
B/C Ratio	over 10				1.7	2.0	1.3	over 10	1.1	1.2	1.6		
1 Benefits-1990	0				1,600	240	170	120	260	50	50	1,530	4,020
Benefits-2020	1,070				4,270	330	330	160	490	100	100	680	7,530
Costs[1]	140				20,150	1,520	1,670	140	3,560	390	390	-	27,960
2 Benefits-1990	0				30	130	90	60	140	30	30	800	1,310
Benefits-2020	790				60	240	240	120	360	70	70	510	2,460
Costs[1]	80				420	810	880	80	1,880	210	210	-	4,570
3 Benefits-1990	0				0	230	160	120	260	50	50	1,460	2,330
Benefits-2020	1,460				0	440	440	220	700	130	130	840	4,360
Costs[1]	140				0	1,470	1,610	140	3,450	540	370	-	7,720
4 Benefits-1990	0				400	420	290	210	460	80	80	2,660	4,600
Benefits-2020	990				5,630	300	300	150	450	90	90	640	8,640
Costs[1]	250				8,800	2,650	2,900	250	6,170	970	670	-	22,660
5 Benefits-1990	0				130	370	260	180	400	70	70	2,300	3,780
Benefits-2020	2,250				250	680	680	340	1,020	200	200	1,460	7,080
Costs[1]	220				600	2,300	2,520	220	5,370	840	580	-	12,650
6 Benefits-1990	0				0	50	40	30	60	10	10	310	510
Benefits-2020	320				0	100	100	50	150	30	30	180	960
Costs[1]	30				0	320	350	30	750	120	80	-	1,680
7, 8 & 9:													
Benefits-1990	0				0	20	10	10	10	0	0	150	200
Benefits-2020	130				0	40	40	20	60	10	10	80	390
Costs[1]	10				0	130	150	10	310	50	30	-	690
Total:													
Benefits-1990	0				2,160	1,460	1,020	730	1,590	290	290	9,210	16,750
Benefits-2020	7,010				10,210	2,130	2,130	1,060	3,230	630	630	4,390	31,420
Costs[1]	870				29,970	9,200	10,080	870	21,490	3,120	2,330	-	77,930

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[1] - Expressed as present worth of all initial and future costs discounted to 1970 at 6 7/8 percent.

TABLE 9B _RIVERINE FLOOD DAMAGE REDUCTION-- COMPOSITE PLAN

(in thousands of 1970 dollars)

Subregion, benefits and costs		REDUCE FLOODING				MINIMIZE DAMAGES			CONTROL FLOOD PLAIN DEVELOPMENT			ACCEPT THE DAMAGE	TOTAL
	Modify hurricanes	Control land runoff	Impound flood waters	Improve channel capacity	Confine flood waters	Flood proof- voluntary	Flood proof- involuntary	Forcast warn, evacuate	Regulate land use	Educate	Apply other Gov't programs		
B/C Ratio	over 10			1.4		2.0	1.3	over 10	1.1	1.2	1.6		
1 Benefits-1990	0			630		60	40	20	70	10	10	410	1,250
Benefits-2020	120			1,180		120	120	40	180	40	40	520	2,360
Costs[1]	10			7,300		390	430	20	910	140	100	-	9,300
2 Benefits-1990	0			0		50	40	20	60	10	10	320	510
Benefits-2020	100			0		100	100	30	150	30	30	420	960
Costs[1]	10			0		320	350	20	750	120	80	-	1,650
3 Benefits-1990	0			1,260		160	110	50	160	30	30	1,050	2,850
Benefits-2020	300			2,340		300	300	90	380	90	90	1,430	5,320
Costs[1]	30			13,780		1,000	1,100	60	2,110	370	250	-	18,700
4 Benefits-1990	0			1,220		60	40	20	70	10	10	430	1,860
Benefits-2020	150			1,980		150	150	50	230	50	50	670	3,480
Costs[1]	10			11,900		400	440	30	940	150	100	-	13,970
5 Benefits-1990	0			690		230	160	70	250	50	50	1,460	2,960
Benefits-2020	430			1,300		430	430	130	640	130	130	1,930	5,550
Costs[1]	50			5,200		1,430	1,570	90	3,340	520	360	-	12,560
6 Benefits-1990	0			270		20	10	10	20	0	0	150	480
Benefits-2020	40			500		40	40	10	60	10	10	190	900
Costs[1]	0			4,000		130	150	10	300	50	30	-	4,670
7, 8 & 9:													
Benefits-1990	0			0		0	0	0	0	0	0	0	0
Benefits-2020	0			0		0	0	0	0	0	0	0	0
Costs[1]	0			0		0	0	0	0	0	0	-	0
Total:													
Benefits-1990	0			4,070		580	400	190	630	110	110	3,820	9,910
Benefits-2020	1,140			7,300		1,140	1,140	350	1,640	350	350	5,160	18,570
Costs[1]	110			42,180		3,670	4,040	230	8,350	1,350	920	-	60,850

[1] - Expressed as present worth of all initial and future costs discounted to 1970 at 6 7/8 percent.

Detailed application of the Composite Plan for each measure in each subregion for the near term (1990) and long term (2020) is shown in Tables 9A and 9B.

10.4 Comparison of the three plans.

Figure 4 is a comparison of the three plans for the region as a whole. It is based on tables 7, 8 and 9.

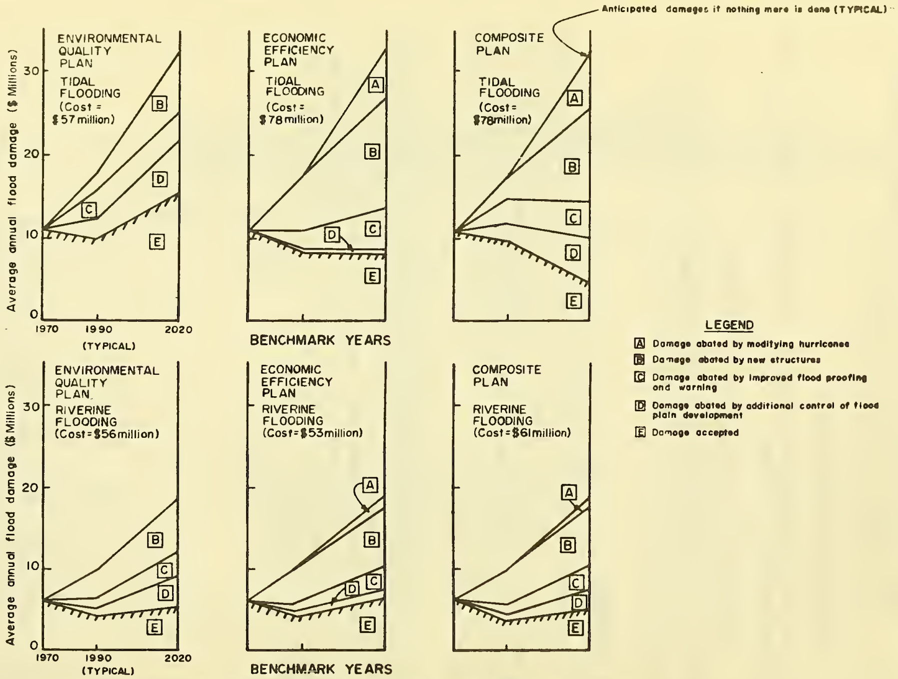
10.5 Analysis of the Composite Plan by subregion.

Figure 5 depicts the extent to which average annual damages can be abated by the Composite Plan over the next 50 years. It is based upon Table 9.

10.6 Priorities

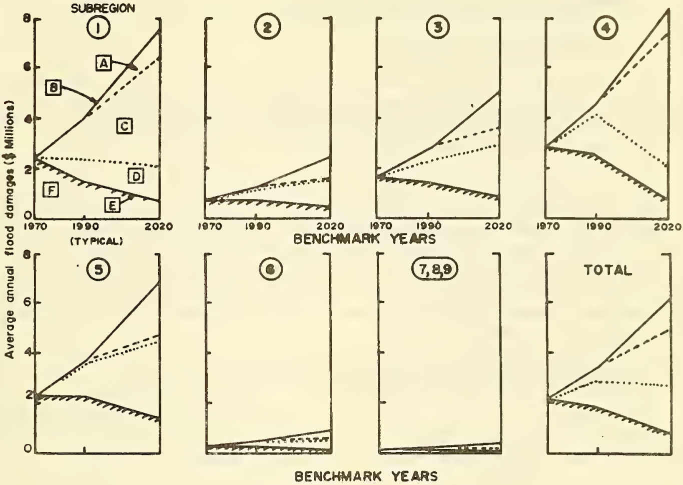
Priorities in this report indicate the relative importance of implementing the recommendations. In general, first priority is given to measures promising (1) a reasonably high degree of flood damage abatement, (2) with a good environmental and/or economic rating, and (3) with no poor EQ, NED or SW rating. Other special considerations can override. When they do, they are so indicated.

Second priority is given to all other recommended measures. All measures are intended to be initiated before 1990 except three--hurricane modification and tidal flood projects at Stratford and Mystic. The first is deferred until current uncertainties regarding secondary efforts are successfully resolved; however, major research effort is proposed now. The two tidal flood projects are deferred until such a time as they engender favorable public support.

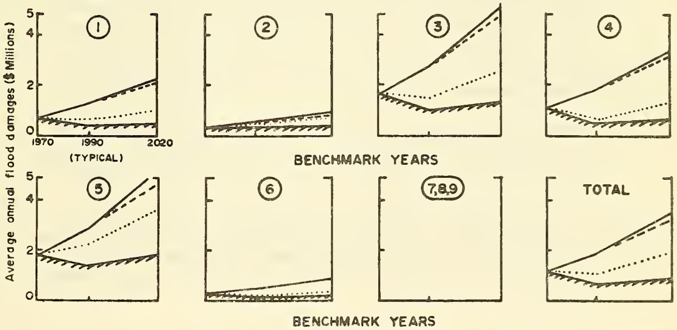


A COMPARISON OF THE THREE PLANS --- THEIR DAMAGE REDUCTION CAPACITY

FIGURE 4



TIDAL DAMAGE



RIVERINE DAMAGE

LEGEND

A Hurricane modification
B Damages with no plan
C Structural measures
D Non-structural measures
E Damages with composite plan
F Damage accepted

FLOOD DAMAGE REDUCTION — COMPOSITE PLAN

FIGURE 5

11.0 WORK GROUP RECOMMENDATIONS

11.1 Over-all recommendations

To provide a coordinated basis for reducing flood damages over the next 50 years, it is recommended that the Composite Plan be adopted by the New England River Basins Commission, the States of Connecticut and New York and the U. S. Water Resources Council.

The Plan is expected to reduce average annual flood losses from about $27 million to $13 million in 1990 and from about $50 million to $10 million in 2020. This is an aggregate savings of about $1 billion over the next 50 years. The program will cost about $139 million expressed as the present worth of all future investment, operating and maintenance costs. Project costs will be about $72 million, with 50 - 70 percent borne by the U. S. Government. Most of the $67 million non-project costs falls directly upon the citizens of the region.

11.2 Recommendations for implementing the Composite Plan

The following 11-point program is recommended for implementing the plan. In each case, the results to be expected, the agencies responsible, the completion date and the action to be undertaken are given.

1. Provide flood control structures. To reduce expected flood losses by about 36 percent, the Corps of Engineers and the Soil Conservation Service should develop 8 tidal and 12 riverine flood control projects in accordance with the schedule shown in Table 10. An integral part of each project must be a land use management program, with appropriate local cooperation to prevent overextension of development in the protected area.

2. Regulate land use. To reduce expected flood losses by about 10 percent, Connecticut should encourage and assist its flood-prone municipal and town governments to study and adopt flood-conscious land use regulations by 1980.

3. Flood proof voluntarily. To reduce expected flood losses by about 6 percent, Connecticut should implement by 1975 a program to educate its flood plain occupants on available floodproofing techniques.

4. Flood proof involuntarily. To reduce expected flood losses by about 6 percent, Connecticut should encourage and assist its flood-prone municipal and town governments to study and adopt flood-conscious building and housing codes by 1980.

5. Improve forecasting, warning and evacuation services. To reduce expected flood losses by about 3 percent, the National Oceanic and Atmospheric Administration should improve its current capability to forecast the paths of hurricanes and warn the public.

6. Educate the public. To reduce expected flood losses by about 2 percent -- and more importantly to lay the basis for most of the developmental control measures proposed herein -- Connecticut should get its communities to complete coastal and riverine flood plain delineation studies, preferably with Federal assistance. First priority, for completion by 1977, should be given to towns currently exposed to over a half million dollars average annual flood loss -- Stratford, Stamford, New London, Stonington, Fairfield, Norwalk, Groton, Westport, New Haven, Milford, Greenwich and Bridgeport.

7. Qualify for flood insurance. To see that their flood-prone residents are made eligible for Federal flood insurance, Connecticut and New York should encourage and assist their flood, prone municipal and town governments to study and qualify for the National Flood Insurance Program -- with the objective of getting all eligible communities either to qualify or to reach a studied decision against participation.

8. Modify hurricanes. To reduce expected flood losses by about 16 percent, the National Oceanic and Atmospheric Administration should intensify its current research efforts and achieve an environmentally and socially acceptable capability by 2000 or earlier to modify hurricanes threatening the region or to divert them out to sea.

9. Apply other flood-related government programs. To reduce expected flood losses by about 2 percent, Connecticut should assist its municipal and town governments in applying other Federal and State programs in flood-conscious ways.

10. Assist in emergencies. To mitigate human suffering, the Department of Housing and Urban Development and the Corps of Engineers should maintain their current capabilities to assist during flood disasters.

11.3 Accept some of the damages. About 19 percent of the damages in 2020 (and 48 percent in 1990) should be accepted as beyond control in environmentally, economically and socially accepted ways.

TABLE 10 FLOOD CONTROL PROJECTS IN THE COMPOSITE PLAN

Subregion/ project	By whom (primarily)	Overall evaluation Good, Fair or Poor			Annual flood Damages Abated ($million)		Cost, present ($ million)	Notes
		Env.	Eco.	Soc.	1990	2020		
First priority:								
1-Thamesville	CE	F	G	F	.5	.8	2.9	
1-Montville	CE	F	G	F	.3	.6	1.0	
1-New London	CE	P	F	G	.9	1.6	13.9[2]	
1-Yantic R.	SCS	F	F	G	.6	1.2	7.3	
2-Point of Woods	CE	G	F	F	nil	.1	0.4	
3-Harbor Brook	SCS	F	G	G	.2	.4	2.0	
3-West R.(N. Haven)	SCS	F	G	G	.3	.6	3.0	
3-Neck R.	SCS	F	F	G	nil	nil	0.1	
3-Munger Brook	SCS	F	F	G	nil	nil	0.3	
3-Farm River	SCS	F	F	G	.1	.1	1.0	
3-Farm Brook	SCS	F	G	G	.2	.4	1.6	
4-Trumbull Lake	CE	G	G	G	1.2	2.0	11.9	
5-Norwalk River	SCS	F	G	G	.7	1.3	5.2	
5-Westport	CE	F	G	F	.1	.3	.6	
6-Blind Brook	SCS	G	F	G	.3	.5	4.0	
(subtotal)					5.4	9.9	55.2	
Second priority:								
1-Mystic	CE	P	F	F	-	1.3	2.4	1
3-Muddy River	SCS	F	F	G	0.1	0.1	0.8	
3-Quinnipiac R.	SCS	F	F	G	0.3	0.6	5.0	
4-Stratford	CE	P	G	F	-	4.9	6.2	1
4-Fairfield	CE	F	G	F	.4	0.8	2.6	
(subtotal					0.8	7.7	17.0	
Total					6.2	17.6	72.2	

1 - The Mystic and Stratford projects are deferred until the 1990-2020 period. Estimated costs are $8.9 million and $23.6 million respectively. Lower entries in the cost column reflect the present (1970) worth of these future costs.

2 -Project cost estimate to be revised to reflect reformulated project.

11.4 Tabulation of recommendations.

The above recommendations are summarized in Table 11.

TABLE 11. SUMMARY OF RECOMMENDATIONS IN THE COMPOSITE PLAN

Accommodation	By whom (Primarily)	Overall evaluation Good, Fair or Poor			Annual flood damages abated ($ million)		Cost, present worth ($million)	Notes
		Environmental	Economic	Social	1990	2020		
First priority:								
Provide flood control structures	Corps, SCS				5.4	9.9	55.2	1
Modify hurricanes	NOAA	P	G	G	.0	8.1	1.0	2
Regulate land use	Local	G	F	G	2.2	4.8	29.8	3
Flood proof voluntarily	Citizen	F	G	G	2.1	3.3	12.9	
Flood proof involuntarily	Local	F	F	F	1.4	3.3	14.1	
Qualify for flood insurance	Local	F	P	G	.0	.0	unk	4
					11.1	29.4	113.0	
Second priority:								
Provide flood control structures	Corps, SCS				0.8	7.7	17.0	1
Forecast, warn, evacuate	NOAA	F	G	G	.9	1.4	1.1	
Educate the public	Fed&State	F	P	F	.4	1.0	4.7	
Apply other gov't programs	Fed&State	G	F	G	.4	1.0	3.2	
Assist in emergencies	HUD, CE	F	G	G	.0	.0	(5.8)	
					2.5	11.1	26.0	
Accept the damages	Citizen	F	P	P	13.0	9.5	NA	
TOTAL					26.6	50.0	139.0	5

1-Summary of Table 10. See that table for individual project evaluations.

2-Low environmental rating offset by potentially outstanding flood damage abatement.

3-Includes flood plain delineation, a prerequisite for some land use regulations.

4-Total cost unknown but some cost data is found in Appendix F.

5-Capitalized value of estimated $0.4 million annually. Not included in totals.

12. FINAL RECOMMENDATIONS

> The preceeding recommendations have not necessarily been approved by the New England River Basins Commission. At the time of this report's publication, the draft main report of the Long Island Sound Regional Study is undergoing public review and comment for consideration in the final document. The FINAL RECOMMENDATIONS on Flood Damage Reduction are therefore to be found only in the final version of the Study's main report--to be published in the Spring of 1975.

The findings and conclusions of this planning report are based on extensive coordination with interested Federal and State agencies and private interests. As a result of this coordination and the views expressed at two sets of public meetings, the final plan was formulated. The major content of that plan has the general endorsement of study participants. There have been discussions with the two States with regard to types of measures required (structural or non-structural) to protect agreed-upon damage prone areas. The Corps findings are based largely on the extensive hurricane studies done in the past, updated to the extent possible within study constraints. However, the Corps recognizes the preference of the State of Connecticut for a non-structural management approach to tidal flood protection. The earlier hurricane studies did consider non-structural approaches, but not based on current criteria of Federal involvement as expressed in Section 73 of the 1974 River and Harbor Act. For this reason it is recommended that the tidal flood prone areas be given an extensive detailed study of survey scope, under current criteria, to assure that each project area will have the best plan possible.

The tidal projects presented in this report were selected on the basis of certain criteria, the main one being the benefit/cost ratio. In this respect, these projects represent areas of high damage concentration. There are many areas of a scattered damage-prone nature, which should be addressed by the non-structural management guidelines suggested in this report.

APPENDIX A

SELECTED REFERENCES

1. Congress, House of Representatives and Senate, Public Law 71, 84th Congress, 1st Session, approved 15 June 1955 (S. 414).

2. Congress, House of Representatives. Document 600, 87th Congress, 2nd Session, October 2, 1962, Hurricane Survey of Fairfield, Connecticut. (U. S. Army Corps of Engineers)

3. Department of Commerce, National Hurricane Research Project, Report No. 28.

4. Congress, House of Representatives. Document 411, 87th Congress, 2nd Session, May 21, 1962 Hurricane Survey of Mystic, Connecticut. (U. S. Army Corps of Engineers)

5. Congress, House of Representatives. Document 478, 87th Congress, 2nd Session, July 16, 1962, Hurricane Survey of New London, Connecticut. (U. S. Army Corps of Engineers)

6. Congress, House of Representatives. Document 292, 88th Congress, 2nd Session, April 6, 1964, Hurricane Survey of Stratford, Connecticut. (U. S. Army Corps of Engineers)

7. Congress, House of Representatives. Document 412, 87th Congress, 2nd Session, May 21, 1962, Hurricane Survey of Westport, Connecticut. (U. S. Army Corps of Engineers)

8. Congress, House of Representatives. Document 210, 86th Congress, 1st Session, August 4 1959, Hurricane Survey of Stamford, Connecticut. (U. S. Army Corps of Engineers)

9. North Atlantic Regional Water Resources Study - Appendix F, Upstream Flood Prevention and Water Management, May 1970.

10. United States Department of Agriculture, Soil Conservation Service, Watershed Work Plans: Yantic River Watershed, November 1971
    Norwalk River Watershed, February 1972
    Spaulding Pond Brook Watershed, November 1963
    Farm Brook Watershed, April 1962

11. U.S. Water Resources Council, Water and Related Land Resources, Establishment of Principles and Standards for Planning, Federal Register, Vol. 38, No. 174, September 10, 1973.

12. Personal communication, from David W. Stickel, Holyoke Community College, to David Harrision, Connecticut River Basin Program, NERBC, November 1973.

13. U.S. Army Corps of Engineers, Office of the Chief of Engineers, Flood Proofing Regulations, June 1972.

14. Proposed National Oceanic and Atmospheric Administration Rules on Coastal Zone Management Program Development Grants, June 13, 1973.

15. NERBC, Plan of Study, Long Island Sound Regional Study, August 1, 1971.

16. U.S. Water Resources Council, Regulation of Flood Hazard Areas to Reduce Flood Losses, 2 volumes, undated, circa 1972.

17. North Atlantic Regional Water Resources Study, Appendix E, Flood Damage Reduction and Water Management for Major Rivers and Coastal Areas, May 1972.

18. Howard, R.A., Matheson, J.E., and North, D.W., "The Decision to to Seed Hurricanes", Science, 16 June 1972, Volume 176, Number 4040.

19. Personal communication from Dr. Cecil Gentry, Director, National Hurricane Research Center, Miami, Florida, to William V. McGuinness, Jr., LIS Study, February 1974.

APPENDIX B

GLOSSARY

BASIN - The tract of land drained by a stream and its tributaries. Same as watershed.

DESIGN FLOOD - The particular flood discharge which is the maximum safe flow for a proposed flood control improvement.

FLOOD PLAIN - The low flat lands adjacent to a watercourse and subject to overflow therefrom.

FLOOD PLAIN MANAGEMENT - A term applied to the full range of public policy and action for insuring wise use of the flood plains. It includes everything from collection and dissemination of flood control information to actual acquisition of flood plain lands, including the enactment and administration of flood plain regulations including building codes and the building of flood modifying structures.

FREQUENCY - The probability that a specific flood will be equalled or exceeded in a given year. It is also the reciprocal of the average recurrence interval.

MEAN SEA LEVEL - (msl) Average height of the sea for all stages of the tide. It may be obtained by averaging hourly heights and its precision depends upon the number of years of observation.

NONSTRUCTURAL MEASURES - Flood plain management measures, other than structural measures, designed to reduce flood damage and damage potential. These measures are generally aimed at reducing damages by regulating people's usage of flood prone areas or providing disaster assistance.

RUNUP - The rush of water up a structure or ground slope on the breaking of a wave. Also "uprush". The amount of runup is the vertical height above the still water level that the rush of water reaches.

STORM SURGE - That rise above normal water level on the open coast due only to the action of wind stress on the water surface. Storm surge resulting from a hurricane also includes that rise in level due to atmospheric pressure reduction as well as due to wind stress.

STRUCTURAL MEASURES - Flood control works constructed to lower flood heights or provide barriers against flood waters.

APPENDIX C

TIDAL FLOOD DAMAGE BY COMMUNITY

Community	Shore Length (miles)	Principal Center of Damage	Structural Measures Considered	Damage Estimates ($1,000 1970) 1954	1938	Footnote 1	Footnote 2	Average Annual Flood Damages[3]
Subregion 1								
1) Stonington	18	White Beach,Stonington Village Stonington Point	Dikes, Dikes Dikes	5,700	8,800			635
Mystic H.D.(411)	28	Mystic	Dikes,Navigation Gate			1,900	1960	472
2) Groton	31	Groton Long Point Area	Dikes, Gate	3,000	6,000			
Mystic H.D.(411)	(28)	West Mystic	Dikes, Navigation Gates			1,900	1960	
3) Ledyard	7.5	Scattered	Minor Damages	Minor	Minor			--
4) Preston	4.7	Scattered	Minor Damages	Minor	Minor			--
5) Norwich	6.1	Thamesville	Dikes, Walls & Pumping Stations	1,400	6,000			274
6) Montville	9.0	Montville Station	Dikes & Walls	850	1,000			193
7) New London	1.3	Ocean Beach	Sandfill & Dikes	5,000	6,400			753
Project H.D.(478)	8.5	Bentleys Creek,Shaw Cove				3,800	1961	
8) Waterford	22	Niantic Bay,Ridgewoor Area	Minor Damages	400	500			--
9) East Lyme	18	Oak Beach	Sandfill & Dikes	1,100	1,300			182
			Subtotals	17,400	30,000	7,600		2,509
Subregion 2								
10) Old Lyme	23	White Sands Beach, Sound View, Point O'Woods	Sandfill & Dikes	2,000	2,400			302
11) Old Saybrook	23	Chalker Beach	Sandfill & Dikes	1,400	1,600			265
12) Westbrook	5	West Beach,Coral Sands, Middle Beach	Sandfill & Dikes	850	1,000			163
13) Clinton	12	Harbor View,Maplewood Drive	Dikes & Walls	300	400			78
			Subtotals	4,550	5,400			815
Subregion 3								
14) Madison	9	Canoe Harbor,Oak Avenue, Shoreline Drive	Sandfill & Dikes	850	850			145
15) Guilford	12	Vineyard Point,West River, Whitfield Street	Dikes	300	300			91
16) Branford	21	Branford Point, Indian Neck Avenue Bridge Indian Neck Point	Barrier w/Gate, Dikes & Walls Barrier across Harbor	1,600	1,500			353
17) East Haven	2.3	West Silver Sands, Silver Sands,Momaugin Beaches	Sandfill & Dikes	850	850			332
18) New Haven	15	Fair Haven	Walls & Dikes	1,100	1,100			331
19) West Haven	7	Oyster River Beach,Bradley Point West River,Elm & Main Sts.	Dikes, Sandfill,Street Gates Dikes	300	300			104
20) Milford	20	Cedar Beach to Fort Trumbull Bayview Point Beach to Pond Point	Dikes & Sandfill Dikes	600	600			376
			Subtotals	5,600	5,500			1,732
Subregion 4								
21) Stratford	9.1	Scattered	Uneconomical	1,700	1,800			2,015
Project H.D.(292)	5.0	Industrial,Residential & Public Property	Dikes & Pumping Stations			3,600	1970	

APPENDIX C (Contd)

TIDAL FLOOD DAMAGE BY COMMUNITY (Contd)

Community	Shore Length (miles)	Principal Center of Damage	Structural Measures Considered	Damage Estimates ($1,000 1970) 1954	1938	Footnote 1	Footnote 2	Average Annual Flood Damages
22) Bridgeport	20	Seaside Park, Tongue Point Pequonnock River	Raising Streets, Dikes & Walls Sheet Piling & Pumping Station	1,000	2,400			330
23) Fairfield	7.8	Ash Creek	Not Feasible	850	1,800			535
Project H.D.(600)	3.4	Pine Creek Fairfield Beach, Jennings Beach	Dikes, Stop Logs, Sandfill			1,240	1970	
			Subtotals	3,550	6,000	4,840		2,880
Subregion 5								
24) Westport	5.5	Saugatuck River, Green Farms, Saugatuck Shores Business District	Barrier Crossings, Sandfill, Dikes & Walls	1,300	1,600			398
Project H.D (412)	1.0	Compo Beach Area	Sandfill & Impermeable Groins			400	1960	
25) Norwalk	17	Rowayton, Harborview, South Norwalk	Walls, Dikes & Sandfill	1,400	2,500			492
26) Darien	15	Scattered	Uneconomical	600	600			207
27) Stamford	11	West Bank of West Branch Harbor, Shippen Point, Westcott Cove-Holly Pond Area	Uneconomical	3,800	7,300			904
Project H.D.(210)	2	East Branch Harbor, West Branch Harbor	Barrier & Navigation Gate	(completed project)		7,900	1969	
28) Greenwich	26	Cos Cob Area, Rocky Point, Greenwich Cove	Dikes	900	1,000			363
			Subtotals	8,000	13,000	8,300		2,364
NEW YORK								
Subregion 6								
29) Portchester	1.1	Scattered	Not Feasible		Minor			--
30) Rye	9.8	Milton Point, Blind Brook	Minor Damage		1,300			130
31) Mamaroneck	7.1	Scattered	Minor Damage		950			95
32) Larchmont	4.1	Scattered	Minor Damage		Minor			--
33) New Rochelle	7.2	Scattered	Minor Damage		950			95
34) Pelham Manor	0.3	Scattered	Minor Damage		Minor			--
35) Bronx	16	Scattered	Minor Damage		Minor			--
36) City Island and Hart Island	3.5 2.0	Scattered	Minor Damage		Minor			--
37) Queens	8.1	Scattered	Minor Damage		Minor			--
38) North Hempstead	25	Scattered	Minor Damage		Minor			--
39) Oyster Bay	30	Scattered	Minor Damage		Minor			--
			Subtotals		3,200			320
Subregion 7								
40) Huntington	27.7	Caumsett State Park Asharokeo Beach	Lack of local cooperation Uneconomical		500			50
41) Smithtown	22.8	Sunken Meadow State Park Short Beach Back of Long Beach	Artificial Placement of beach fill		Minor			--

APPENDIX C (Contd)

TIDAL FLOOD DAMAGE BY COMMUNITY (Contd)

Community	Shore Length (miles)	Principal Center of Damage	Structural Measures Considered	Damage Estimates ($1,000 1970)		Footnote 1	Footnote 2	Average Annual Flood Damages
				1954	1938			
42) Brookhaven	34.2	Port Jefferson Harbor Mt. Sinai Harbor	Uneconomical		600			60
			Subtotals		1,100			110
Subregion 8								
43) Riverhead	14.5	Wading River	Built-up Beach		Minor			--
44) Southold	23.5	Hashamonuck Beach Plum Island	Minor Damage		200			20
			Subtotals		200			20
Subregion 9								
45) Fishers Island	18	Elizabeth Airfield, South Eel Cove, Hay Harbor, West Harbor	Insignificant Minor Damage		Minor			--
Total length in miles	681.10		Totals	39,100	64,400	20,700		10,750

1) Recurring 1938 damages preventable by structural measures considered.

2) The damage estimates are based on the level of development existing in the year entered in this column.

3) In thousands of 1970 dollars, at 1970 level of development.

APPENDIX D

RIVERINE FLOOD PRONE AREAS AND FLOODWATER DAMAGES

(Areas in 1,000 Acres & Damages in $1,000,000)

(1970 dollars and 1970 level of development)

Subregion	River Basin	Drainage Area	Flood Prone Areas	Total Average Annual Dollars	100-Year Storm Damage Dollars
1	Fourmile River	4.10	0.28	0.001	0.014
	Bride Brook	3.09	0.26	0.016	0.230
	Pataguanset River	5.68	0.33	0.027	0.380
	Niantic River	19.97	0.66	0.007	0.104
	Jorden Cove	6.40	0.20	0.008	0.108
	Shetucket River	812.16	4.31	0.181	2.585
	Yantic River	62.98	1.59	0.202	2.887
	Thames River	945.92	7.78	0.329	4.700
	Poquonock River	13.57	0.07	0.003	0.045
	Mystic River	16.96	0.64	0.012	0.164
	Copps Brook	5.02	0.19	0	0
	Wesquetequock River	7.94	0.17	0	0.001
	(Total Subregion 1)		16.48	0.785	11.218
2	Indian Creek	5.06	0.28	0.016	0.234
	Menunketesuck River	11.07	0.34	0.012	0.177
	Patchogue River	5.04	0.23	0.035	0.505
	Oyster River	4.04	0.19	0.003	0.050
	Salmon River	55.30	0.89	0.064	0.914
	Warehouse Brook	0.88	0.07	0.005	0.072
	Whalebone Creek	9.41	0.24	0.001	0.015
	Chester Creek	9.15	0.51	0.093	1.327
	Deep River	4.63	0.36	0.059	0.344
	Joshua Creek	1.56	0.09	0.001	0.014
	Eightmile River	38.53	1.61	0.024	0.342
	Lieutenant River	7.74	0.21	0.004	0.562
	Threemile River	1.56	0.08	0.0003	0.004
	(Total Subregion 2)		5.10	0.317	4.560

Subregion	River Basin	Drainage Area	Flood Prone Areas	Total Average Annual Dollars	100-Year Storm Damage Dollars
3	Naugatuck River	198.40	1.33	0.278	3.970
	Wepawaug River	12.67	1.10	0.071	1.014
	Indian River	8.45	0.45	0.014	0.194
	Cove River	2.40	0.20	0.085	1.215
	West River	23.04	0.94	0.203	2.901
	Mill River	24.64	1.17	0.215	3.077
	Quinnipiac River	106.24	3.51	0.530	7.572
	East Haven River	17.02	1.15	0.128	1.824
	Branford River	17.54	0.87	0.191	2.725
	West River	11.52	0.49	0.027	0.384
	East River	20.22	1.47	0.020	0.287
	Hammonassett River	31.62	1.47	0.017	0.240
	(Total Subregion 3)		14.15	1.779	25.403
4	Sasco Brook	6.53	0.14	0.006	0.092
	Mill River	20.99	0.74	0.060	0.852
	Ash Creek	9.66	0.19	0.154	2.207
	Pequonnock River & Trumbull Lake	18.82	0.99	0.845	12.060
	Yellow Mill Channel	3.01	0.16	0.019	0.267
	Johnsons Creek	2.72	0.08	0.033	0.468
	Halfway River	1.59	0.07	0.0003	0.004
	Far Mill River	16.58	1.17	0.029	0.414
	Pumpkin Brook	3.74	0.14	0.008	0.120
	Beaver Brook	1.83	0.09	0.006	0.087
	(Total Subregion 4)		3.77	1.160	16.571
5	Byram River	18.30	0.66	0.271	3.867
	Horseneck River	4.00	0.20	0.129	1.842
	Greenwich Creek	1.48	0.38	0.040	0.578
	Mianus River	22.14	0.71	0.042	0.597
	Rippowan River	23.94	0.57	0.539	7.704
	Noroton River	7.62	0.50	0.315	4.498
	Stony Brook	4.14	0.19	0.025	0.354
	Tokeneke Brook	0.78	0.04	0	0

Subregion	River Basin	Drainage Area	Flood Prone Areas	Total Average Annual Dollars	100-Year Storm Damage Dollars
5	Fivemile River	8.26	0.49	0.055	0.785
	Norwalk River	41.09	1.11	0.309	4.414
	Saugatuck River	59.65	1.45	0.122	1.745
	Muddy Brook	1.82	0.03	0.007	0.107
	(Total Subregion 5)		6.33	1.854	26.49
6	Blind Brook	19.95	0.36	0.201	2.880
	Beaver Swamp Brook	3.01	0.10	0.018	0.257
	Manaroneck & Sheldrake River	44.42	0.18	0.080	1.149
	Hutchinson River	3.69	0.08	0.005	0.077
	(Total Subregion 6)		0.72	0.304	4.363
	TOTALS FOR LISS AREA		46.55	6.199	88.605

Note: Riverine flood damages in Subregions 7, 8, and 9 are minor.

APPENDIX E

STATUS OF FLOOD PLAIN REGULATIONS BY COMMUNITY

CONNECTICUT

(As of October 10, 1974)

Municipality	Flood Plain Zoning Ordinance	Conservation Regulations	Building Code	Health Code	Flood Insurance Eligibility (4)	
					EP	R
Subregion 1						
Bozrah	No	No	State	State	EP	
Colchester	No	Pending	State	State	No	
East Lyme	1968	1972 - 73	State	State	EP	
Franklin	No	No	State	State	No	
Griswold	No	No	State	State	No	
Groton	1961	1972	State	State	EP	
Ledyard	No	No	State	State	No	
Lisbon	No	No	State	State	No	
Montville	No	No	State	State	EP	
New London	No	1972	State	State	EP	
North Stonington	No	No	State	State	No	
Norwich	1973	No	State	State	EP	
Preston	No	No	State	State	No	
Salem	No	No	State	State	No	
Stonington	No	1977	State	State	Pending	
Sprague	No	No	State	State	No	
Voluntown	No	No	State	State	No	
Waterford	No	1972	State	State	EP	

APPENDIX E
(Contd)

STATUS OF FLOOD PLAIN REGULATIONS BY COMMUNITY

CONNECTICUT

(As of October 10, 1974)

Municipality	Flood Plain Zoning Ordinance	Conservation Regulations	Building Code	Health Code	Flood Insurance Eligibility (4) EP	R
Subregion 2						
Chester	No	Yes	State	State(1)	EP	
Clinton	Yes	Yes	State	State(1)	EP	
Deep River	No	No	State	State	EP	
Essex	1971	Yes	State	State(1)	EP	
Killingworth	No(3)	No	State	State(1)	No	
Lyme	1970	Yes	State	State(1)	EP	
Old Lyme	No	Yes	State	State(1)	EP	
Old Saybrook	1972	Yes	State	State(1)	EP	
Westbrook	No	Yes	State	State(1)	EP	
Subregion 3						
Bethany	No	No	State	State	No	
Branford	Yes	No	State	State	EP	
East Haven	Pending	No	State	State	EP	
Guilford	Pending	No	State	State	EP	
Hamden	1970	No	State	State	EP	
Madison	No	No	State	State	EP	
Meriden	No	No	State	State	EP	
Milford	Yes	No	State	State	EP	
New Haven	No	Yes	State	State	EP	
North Branford	Pending	No	State	State	EP	

APPENDIX E
(Contd)
STATUS OF FLOOD PLAIN REGULATIONS BY COMMUNITY

CONNECTICUT
(As of October 10, 1974)

Municipality	Flood Plain Zoning Ordinance	Conservation Regulations	Building Code	Health Code	Flood Insurance Eligibility (4)
					EP R
North Haven	No	No	State	State	EP
Orange	No	No	State	State	EP
Wallingford	Yes	No	State	State	EP
West Haven	Pending	No	State	State	EP
Woodridge	No	No	State	State	No
Subregion 4					
Bridgeport	Pending	Yes(2)	State	State	EP
Easton	No	Yes(2)	State	State	Pending
Fairfield	Yes	Yes(2)	State	State	EP
Munroe	Pending	Yes(2)	State	State	Pending
Stratford	No	Yes(2)	State	State	EP
Trumbull	No	Yes(2)	State	State	EP
Ansonia	Yes	No	State	State	No
Derby	Yes	No	State	State	EP
Seymour	NA	No	State	State	No
Shelton	NA	No	State	State	EP

APPENDIX E
(Contd)

STATUS OF FLOOD PLAIN REGULATIONS BY COMMUNITY

CONNECTICUT

(As of October 10, 1974)

Municipality	Flood Plain Zoning Ordinance	Conservation Regulations	Building Code	Health Code	Flood Insurance Eligibility (4)	
					EP	R
Subregion 5						
Darien	No(3)	No	State	State	EP	
Greenwich	No(3)	No	State	State	EP	
New Canaan	No(3)	No	State	State	EP	
Norwalk	No(3)	No	State	State	EP	
Stamford	No(3)	No	State	State	EP	
Weston	No(3)	No	State	State	EP	
Westport	No(3)	No	State	Local/State	EP	
Wilton	Yes	Yes	State	State	EP	

(1) State health code is enforced via the town subdivision regulations.

(2) Inland wetlands regulation (P. A. 155).

(3) Covered under subdivision regulation.

(4) EP denotes eligibility under emergency program, R denotes regular program

APPENDIX E
(Contd)

STATUS OF FLOOD PLAIN REGULATIONS BY COMMUNITY

NEW YORK

(As of August 1974)

Municipality (3) (4) (5)	Flood Plain Zoning Ordinance	Conservation Regulations	Building Code	Health Code	Flood Insurance Eligibility EP R(2)
Rye (c)	No	Yes	Yes	No	EP
Mamaroneck(t)	No	Yes	No	No	EP
Mamaroneck(v)	No	Yes	No	No	EP
Scarsdale(v)	No	Yes	No	No	EP
Mount Vernon(c)	No	Yes	No	No	No
Rye(t)	No	Yes	Yes	No	EP
New Rochelle(c)	No	Yes	Yes	No	EP
White Plains (c)	No	Yes	Yes	No	EP
Harrison(t)	NA	NA	NA	NA	EP
Port Chester(v)	NA	NA	NA	NA	EP
Pelham Manor(v)	NA	NA	NA	NA	EP
North Pelham(v)	NA	NA	NA	NA	No
Pelham(v)	NA	NA	NA	NA	No
Eastchester(t)	NA	NA	NA	NA	EP
Bronxville Village	NA	NA	NA	NA	EP
Larchmont(v)	NA	NA	Yes	NA	EP
Bronx(c)	No	No	Yes	Yes	No
Bayville(v)	NA	NA	NA	NA	EP
Lattingtown(v)	NA	NA	NA	NA	EP
Queens(c)	No	No	Yes	Yes	No
Kings Point(v)	NA	NA	NA	NA	EP
Glen Cove(c)	No	Yes	Yes	No	EP

APPENDIX E
(Contd)
STATUS OF FLOOD PLAIN REGULATIONS BY COMMUNITY

NEW YORK

As of August 31, 1974

Municipality (3) (4) (5)	Flood Plain Zoning Ordinance	Conservation Regulations	Building Code	Health Code	Flood Insurance Eligibility EP R(2)
Manorhaven(v)	NA	NA	NA	NA	EP
Port Washington North(v)	NA	NA	NA	NA	EP
Sands Point(v)	NA	NA	NA	NA	EP
Thomaston(v)	NA	NA	NA	NA	EP
Great Neck(v)	NA	NA	NA	NA	EP
North Hempstead(t)	No	No	No	No	EP
Oyster Bay(t)	No	No	Yes	No	EP
Sea Cliff(v)	No	No	Yes	No	EP
Subregion 7					
Nissequoque	NA	NA	NA	NA	EP
Huntington(t)	No	Yes	No	No	EP
Smithtown(t)	No	Yes	No	No	EP
Asharoken(v)	No	Yes	No	No	R
Brookhaven (t)	No	Yes	No	No	R
Lloyd Harbor(v)	No	Yes	No	No	EP
Northport(v)	No	Yes	No	No	EP
Huntington Bay(v)	NA	NA	NA	NA	EP

APPENDIX E
(Contd)

STATUS OF FLOOD PLAIN REGULATIONS BY COMMUNITY

NEW YORK

As of August 31, 1975

Municipality (3) (4) (5)	Flood Plain Zoning Ordinance	Conservation Regulations	Building Code	Health Code	Flood Insurance Eligibility	
					EP	R(2)
Subregion 8						
Riverhead(t)	No	No	Yes	No	EP	
Southold(t)	No	Yes	No	No	EP	
Subregion 9						
Southold (t)	No	Yes	No	No	EP	

(1) NA = Not Available

(2) EP denotes eligibility under emergency program.
R denotes regular program

(3) (c) = city

(4) (t) = town

(5) (v) = village

(6) Except

Note: Listing updated from HUD List 31 December 1974

LONG ISLAND SOUND REGIONAL STUDY

Flood insurance study report status in the State of Connecticut 1 April 1975.

These FIS reports have been completed.

1. New London

These FIS reports have been started or are being revised.

1. Derby
2. Fairfield (Rev)
3. Greenwich
4. Groton (Rev)
5. Guilford
6. Milford (Rev)
7. Norwalk
8. Old Saybrook
9. Stamford (Rev)
10. Stratford
11. West Haven
12. Westport (Rev)

APPENDIX F

DETAILED EVALUATION OF ALTERNATIVE MEASURES

a. The criteria

The 54 criteria listed in the left column of the evaluation matrix below are a synthesis of guidance obtained from many sources. Most notable among them are:

- The Principles and Standards (PAS) of the U.S. Water Resources Council (11).
- Various guidelines for the preparation of environmental impact statements (EIS) required under the National Environmental Policy Act of 1969 (NEPA). The EIS requirements were also incorporated by the WRC in its formulation of the PAS.
- The Coastal Zone Management Act of 1972 (14).
- The LIS Plan of Study (15).
- Guidance from the New England River Basins Commission.
- Concepts developed by study participants.

By far the most significant of these sources was the PAS. For example, the criteria used in the matrix have been grouped so as to correspond with the four "accounts" required by the PAS. The environmental criteria correspond to the environmental quality (EQ) account. The economic criteria correspond to two accounts -- national economic development (NED) and regional development (RD) The social criteria correspond to the account on social well-being.

b. The alternative measures

The 17 alternative measures heading each column on the right of the matrix are a condensation from Table 4, which is found in Section 9 of the body of this report. The measures listed in columns 1-b through 1-e are classes of projects (Major projects are individually evaluated elsewhere in this report.) The other measures can be considered as policy measures. Their application will be widespread throughout this LIS Region.

c. Entries in the matrix

Unless otherwise indicated, entries in the evaluation matrix reflect judgements as to the most likely, overall, long-term and widespread effects of implementing a specified measure (a column) on a specified criterion (a row) -- as perceived from the parochial viewpoint of the criterion. Most entries in the matrix use the following symbols:

- ++outstandingly beneficial
- + significantly beneficial
- 0 not applicable, or benefits and adversities are generally minor
- - significantly adverse
- = severely adverse

Consideration was given to replacing these symbols with numbers (10=++, 8=+, etc) and assigning each criterion a relative weight normalized in such a way that a perfect rating (all ++'s) would score 100 and the worst possible rating (all='s) would score 0. With a computer, each column(measure) could thus be scored and ranked . The evaluation ratings from this report could then be integrated with ratings from the other nine planning reports and be used in assigning priorities and making tradeoffs.

Although such a system is conceptually simple, it was rejected as obfuscating, rather than simplifying an already complex process. Few would agree on the weighting system. Although there are methods for reaching an informed consensus[1], they would further divert attention deeper into methodology and away from a more visible grasp of the factors involved.

Therefore, suggestions that the matrix be made even more complex were resisted. The principal end products of the matrix are the summary environmental, economic and social ratings. The other entries are intended to indicate how the summary ratings were derived and to provided a systematic way of identifying major benefits and adversities for narrative explanation in the report proper, where the measures were weighed and recommendations formulated.

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[1] - The "Delphi" process, for one.

EVALUATION MATRIX

EVALUATION CRITERIA		REDUCE FLOODING					MINIMIZE DAMAGES			CONTROL FLOOD PLAIN DEVELOPMENT					ACCEPT THE DAMAGE			
		Mod'y hurri-canes	Cont'l land run-off	Imp'd flood waters	Improve channel capacity	Confine flood waters	Flood proof vol.	Flood proof invol.	Forec'st warn evacuate	Relocate	Regulate land use	Educate	Control finance	Apply other gov't progs		Fed ins	Comm ins	Assist in emergencies
Column Number		1a	1b	1c	1d	1e	2a	2b	2c	3a	3b	3c	3d	3e	4	5a	5b	5c
1. ENVIRONMENTAL CRITERIA																		
a. Environmental Quality	2																	
(1) Natural Beauty]	3	0	0	0	-	-	0	0	0	0	+	+	+	+	0	0	0	0
(2) Land: Erosion & Sedimentation		++	++	+	+	0	0	0	0	0	+	0	0	0	-	0	0	0
(3) Water: Water Quality	4	++	+	++	0	0	0	0	0	0	+	0	0	0	0	0	0	0
(4) Air: Air Quality	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
b. Ecological Systems	5																	
(1) Terrestrial																		
(a) Plants		0	+	+	0	0	0	0	0	0	+	0	0	0	+	0	0	0
(b) Animals		0	0	+	0	0	0	0	0	0	+	0	0	0	+	0	0	0
(2) Aquatic																		
(a) Plants		=	0	0	-	-	0	0	0	0	0	0	0	0	0	0	0	0
(b) Animals																		
1. Anadromous		-	0	=	-	0	0	0	0	0	0	0	0	0	0	0	0	0
2. Resident																		
a. Cold water		=	0	+ & -	=	0	0	0	0	0	+	0	0	+	0	0	0	0
b. Warm water		0	0	++	-	0	0	0	0	0	0	0	0	+	0	0	0	0
c. Scarce Resources																		
(1) Archeological-Historical	6	+	0	+	0	+	0	+	0	+	++	+	+	0	-	0	0	0
(2) Biological	7	-	-	-	-	-	0	0	0	0	0	-	-	0	0	0	0	0
(3) Geological	8	0	0	0	0	0	0	0	0	0	+	0	0	0	0	0	0	0
d. Irreversible Committments	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
e. Summary Environmental Rating	10	Poor	Good	Fair	Poor	Poor	Fair	Fair	Fair	Fair	Good	Fair	Fair	Good	Fair	Fair	Fair	Fair
2. ECONOMIC CRITERIA																		
a. Benefits	11																	
(1) Annual Benefits	12	*	+	++	+	++	10/10	7/10	#	0	11/16	2/3	2/3	2/3	=	50	30	+
(2) External Benefits (++ is high)	13	++	0	++	0	+	+	+	+	+	+	0	0	+	=	+	+	+
b. Costs																		
(1) Present Worth (= is high)	12	*	-	-	-	-	63	69	#	=	148	23	20	16	0	1,560	Nil	-
(2) Annual Costs (Footnote b)	12	*	-	-	-	-	5/5	5/8	Nil	=	10/15	2/3	2/3	1/2	0	125	Nil	2
(3) External Costs (= is high)	13	=	0	-	-	-	0	0	0	-	-	0	-	0	=	0	0	0
c. B/C Ratio (++ is high)	12	>10	0	+	0	+	2.0	1.3	>10	=	1.1	1.2	1.2	1.6	NA	0.4	0.5	>10
d. Other																		
(1) Jobs (++ is more jobs)	14	++	0	+	0	+	+	+	0	0	0	0	0	0	-	+	+	0
(2) Population (++ is concentrated)	14	+	0	+	0	+	+	+	0	-	+	0	0	0	-	+	0	0
(3) Economic Base & Stability	14	++	0	+	0	+	+	+	0	0	0	0	-	0	-	+	0	+
(4) Environmental Desirability	14	+	0	+	-	=	0	0	0	0	+	+	+	+	-	0	0	0
e. Summary Economic Rating	10	Good	Fair	Good	Fair	Good	Good	Fair	Good	Poor	Poor	Poor	Poor	Fair	Poor	Poor	Poor	Good
3. SOCIAL CRITERIA																		
a. Real Income Distribution																		
(1) Primary Incidence of Benefits		Public	Occupant	Occ.	Occ.	Occ.	Occ.	Occ.	Occ.	Occ. Pub	Pub	Pub	Pub	Pub	Ecologist	Occ	Occ	Occ
(2) Primary Incidence of Costs		Pub	Pub	Pub	Pub	Locality	Occ.	Occ.	Pub	Pub	Occ.	Pub	Occ.	Pub	Occ & Pub	Occ&Pub	Occ	Pub
b. Life, Health & Safety	15	++	0	+	0	0	+	+	++	+	0	+	0	0	=	0	0	++
c. Educational, Cultural, Recreational		+	0	+	0	0	0	0	0	0	0	++	0	0	-	+	0	-
d. Emergency Preparedness																		
(1) Energy Conservation		+	0	0	0	0	0	0	0	-	+	0	0	0	=	0	0	-
(2) Other		+	0	+	0	+	0	0	++	+	0	+	0	0	-	0	0	++
e. Ability to Meet Other Needs	16																	
(1) Land Use		+	0	0	0	0	+	+	0	+	++	+	+	+	0	-0	0	0
(2) Water Quality		++	+	++	0	0	0	0	0	0	+	0	0	0	0	0	0	0
(3) Water Supply		+	0	++	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(4) Shoreline Appearance & Design		0	0	++ & =	-	=	0	0	0	++	++	0	0	+	0	0	0	0
(5) Erosion & Sedimentation		++	++	+	+	0	0	0	0	0	+	0	0	0	0	0	0	0
(6) Flood Damage Reduction		++	+	++	+	++	+	+	+	+	++	+	+	+	=	0	0	0
(7) Recreation		+	0	++	0	-	+	0	0	++	+	0	0	+	0	0	0	0
(8) Fish & Wildlife		++ & =	0	+ & -	-	-	0	0	0	+	0	0	0	++	+ & -	0	0	0
(9) Transportation		+	0	+	+	+	0	0	0	0	-	0	0	+	-	0	0	0
(10) Minerals		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(11) Power		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
f. Legal - Judicial Involvement	17	=	0	-	-	-	0	-	0	-	=	-	-	-	0	0	0	0
g. Institutional																		
(1) Agencies Primarily Responsible		NOAA	SCS	SCS-CE	SCS	CE-SCS	Citizen	HUD	NOAA-CE	State	Comm.	CE, SCS State	HUD State	Various	None	HUD	Comm	HUD, CE
(2) Ease of Administering		=	-	0	+	0	+	-	0	=	-	-	=	Varys	+	-	-	0
(3) Preferability of non-Federal Action	18	0	0	0	0	0	0	=	0	0	0	0	0	0	0	0	0	0
h. Political																		
(1) Ease of Creating Institution	19	-	0	-	0	-	0	-	0	0	=	0	=	Varys	0	0	=	0
(2) Ease of Passing Law	19	-	0	-	0	-	0	-	0	-	=	0	-	Varys	0	0	=	0
i. Other																		
(1) Community Continuity		+	0	+	0	+	+	+	++	-	+	0	0	0	-	++	++	+
(2) Environmental Attractiveness		-	+	-	-	-	0	0	0	0	+	0	0	+	0	0	0	0
(3) Years to Implement		>20	>10	>10	5-10	>10	0-5	5-10	0-5	0-5	0-20	5-10	5-10	0-20	0	0-5	0-5	0-5
j. Summary Social Rating	10	Good	Good	Good	Good	Good	Good	Fair	Good	Good	Fair	Fair	Poor	Good	Poor	Good	Poor	Good
4. APPLICABILITY TO GENERAL OBJECTIVES	20	Only ED	Pref. EQ	Pref. EO	Only ED	Only EOm	Pref ED	Pref ED	Pref ED	Only EQ	Only EQ	Only EQ	Only EQ	Pref EQ	None	Only SW	None	Pref EO

*For column 1a - Entries on rows 2a(1), 2b(1) and 2b(2) are 0/33, 6 and o respectively for tidal flooding and 0/10, 2 and 1 respectively for riverine flooding.

#For column 2c - Entries on rows 2a(1) and 2b(1) are 5/5 and 6 respectively for tidal flooding and 3/3 and 4 respectively for riverine flooding.

FOOTNOTES

1. Not used.

2. Environmental criteria are described below in terms of beneficial effects. Adverse effects should be read as the converse of each statement.

3. Natural beauty benefits result from the protection, enhancement, or creation of open and green space, wild and scenic rivers, lakes, beaches, shores, mountain and wilderness areas, estuaries, or other areas of natural beauty.

4. Water and air quality benefits are reductions in the contaminants in the water and the air without regard (on this row) for the effects of these reductions on other criteria.

5. Benefits to an ecological system reflect broad judgements as to the most likely overall longterm and widespread effects on the system under consideration. For example, an entry of "+" opposite warm water resident aquatic animals (e.g., pickerel) means that (1) considering the overall impacts (on land, water and air quality; habitat; on human uses; etc.) of the measure being evaluated, (2) the net effects (benefits less adversities) on the class of warm water resident aquatic animals will probably be beneficial (a) over the long term (once the immediate effects fade away), and (b) over all or most of the watershed.

   Many ecologists would understandably caution against making such judgements as to net effects They would prefer to estimate only the impacts listed elsewhere in the table (e.g., improved water quality, decreased human activities). They would refrain from estimating the effects of these impacts on any biological system as being beyond the current state of the art or as apt to mislead. To reinforce their point, they might explain for example, that what would probably be "beneficial" to one warm water species might be adverse to another. Even for the same species, they could point out that an apparently beneficial change (e.g., in deer habitat) could produce overpopulation and eventual mass starvation without management (e.g., periodic thinning of the herds).

   Agreeing with these comments, we nevertheless have chosen to estimate net effects To suspend judgements on the effects or to imply that they are so difficult to comprehend that they cannot be factored into the analysis without a major study, however scientifically defensible, is not useful to those who must conscientiously weigh all major considerations before making decisions. Decisions to act or not to act cannot be avoided. They must be made using best available judgements on effects.

6. Archeological-historical benefits are highly site specific. With early recognition, projects and programs can usually be adjusted to preserve these values.

7. Biological benefits on this row are increased opportunities to observe rare and endangered species and the ecological systems upon which they depend with the end of significantly enlarging understanding and appreciation of the natural world as the habitat of man. All programs that would involve any significant construction, inundation or change in land use patterns are rated significantly adverse. This rating is based upon the general expectation that given enough study, almost every area of any size will be discovered to have one or more scarce biological species, or be able to be described as a unique locale for studying one or more such species.

8. Geological benefits are the preservation of outstanding geologic or geomorphologic significance so as to contribute to man's knowledge and appreciation of his physical environment. Although individual projects and program applications could produce significant effects, in general the effects in the LIS Region are probably minor.

9. Irreversibility was the most difficult criterion to evaluate with consistency. Many early concepts of irreversibility almost compelled inaction: if an action could be labeled irreversible or possibly irreversible, the constant conclusion was--do not act until the unknowns are resolved. Little attention was given to the possibility of irreversible effects stemming from inaction. The definition in the PAS requires a more sophisticated evaluation because it does incorporate this concomitant concern for the effects of inaction. According to the PAS (11), beneficial effects on this row are those "resulting from the preservation of freedom of choice to future resource users by actions that minimize or avoid irreversible or irretrievable effects or, conversely, the adverse effects resulting from failure to take such actions, "(underscoring added).

   Another major difficulty is the use of the concept of irreversibility without adequate definition of its range in space and time. Almost every physical action causes irreversible environmental effects at some level (e.g., a house foundation has an irreversible effect on the forest flood it replaces.) If weighed in a broader setting however, (e.g., 10 house foundations in a 100 square mile valley), the environmental effects on the valley may not be at all irreversible. Even when weighed over the long term and over a widespread area, irreversibility is hard to categorize. A flood control dam, for example, could (if later knowledge indicated the wisdom) be used to cause (as well as to minimize) large floods, wetlands formation or unstable stream conditions. In this sense, the major widespread long term effects of the dam could readily be reversed even though the localized effects at the dam site and its impoundment area would indeed be irreversible. With equal force, a land use measure that diverted concentrated development away from the river-adjacent heart of cities into surburban or rural areas would indeed produce an irreversible effect: the development thus diverted --and the infrastructure of new roads and utilities that must be built to serve it -- will rarely move back. On the other hand, if such a land use policy were to be reversed, it is probable that subsequent development would in time be forced to reverse the previously induced dispersion trends. With these thoughts in mind, all entries under this criterion are labeled "o". Those who prefer a different entry should define the setting in which their evaluation is formulated.

10. Summary ratings for environmental, ecological and social criteria are expressed as GOOD, FAIR and POOR depending upon the preponderance of other relevant entries in the table. It should be noted that almost every GOOD (POOR) summary rating was awarded despite one or a few adverse (beneficial) entries. Rarely is any situation all good or bad.

11. Broadly considered, the ratings under economic criteria are essentially identical whether judged from the point of view of economic development or regional development. This follows because of the premise that in the LIS Study national and regional objectives are in general harmony. The study, for example, does not attempt to induce manufacturing to locate here in preference to a more economically efficient location elsewhere nor does it seek favored treatment vis-a-vis other regions in the allocation of national resources. Therefore, entries here generally apply equally to the accounts for national economic development and regional development.

12. All numerical cost and benefit entries have been computed on the basis of constant 1970 dollars, basic economic formulae, an interest rate of 6 7/8 percent as currently prescribed by the WRC, a 100 year economic life for major projects, and an indefinite life for policy measures. Entries for the project-type measures, columns 1-b through 1-e, are general. Specific major projects are evaluated elsewhere in this report. Annual benefits for the policy-type measures consist of two numerals separated by a slash. They reflect an estimate of the percentage of residual damages (average annual flood damage not abated by projects), that can practicably be abated by implementing the policy measure. The first numeral represents 1990, the second 2020. Thus the entry "11/16" for the annual benefits of regulating land use

signifies that about 11 percent of the residual damages in 1990 and 16 percent in 2020 can be abated, if this technique is researched and applied.

Supporting computations are on file at the LIS Study. They are too tedious to repeat in this report, but they can be summarized as follows:

a. List the non-project alternatives and indicate the type of development to which each primarily applies -- existing, future or both.

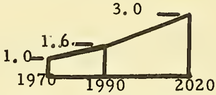
b. Estimate a B/C ratio for each alternative. The ratio is a judgement as to how intensively an alternative might practicably be pursued. For example, voluntary, low-funded, single purpose programs must usually operate at a higher B/C ratio than governmental, well financed, multipurpose programs. For the former, the benefits must be very attractive. For the latter, most remaining economically justifiable benefits can be captured and costs can be distributed among several beneficiary purposes in addition to flood damage reduction.

c Estimate the percentage of damage incurred by each type of development--existing and future--for 1990 and 2020. For 1990, about 62.5 percent of the annual damages then incurred is estimated to be attributed to development already in place in 1970. By 2020, it is estimated that this percentage will drop to 33.3 percent.

d. For damages to existing development, estimate the percentage capable of practicable abatement by each applicable technique in 1990 and 2020 being sure to allow a reasonable percentage as not susceptible to abatement. Repeat for damages to future development.

e. Having estimated the B/C ratios and the benefits, use established economic formulae to compute costs. To facilitate comparison between all measures on a consistent basis, express total costs in terms of present worth -- the initial sum, which when earning 6 7/8 percent interest compounded annually, would meet all initial costs and all subsequent operations and maintenance costs.

For example, if future benefits were as depicted in this typical example (the basis of Tables 1 and 2) --



then the 1970 present worth (PB) of all these future benefits would be approximately 20, computed by the formula:

$$PB = \frac{{}^{b}1970}{(1 + i)} + \frac{{}^{b}1971}{(1 + i)^2} + \ldots\ldots\ldots + \frac{{}^{b}2020}{(1 + i)^{50}}$$

where b = benefits in year indicated, and i = 0.06875 represents the prescribed 6 7/8 percent discount rate.

Expressing PB as a function of 1990 benefits, we have

$$PB = \frac{(20)({}^{b}1990)}{1.6} = 12.5 \ ({}^{b}1990).$$

Since costs equal benefits divided by the B/C ratio.

$$PC = \frac{PB}{B/C} = 12.5 \ \frac{({}^{b}1990)}{B/C}$$

This simplified relationships allows us to estimate PC directly from the previously estimated ${}^{b}1990$ and B/C ratio. For example, if a particular measure would abate 10 percent of the 1990 residual damages at a B/C ratio of 2.0, then

$$PC = 12.5 \ \frac{({}^{b}1990)}{B/C} = \frac{12.5(10)}{2.0} = 62.5$$

Say 63 percent of residual 1990 damages

f. All costs and benefits have thus far been estimated as a percentage of the annual damage sustained in each of the benchmark years. Therefore, it is a simple matter to apply them to the residual damages in each subregion. This is the way Tables 6, 7 and 8 in the report proper were constructed. For example, consider voluntary flood proofing in Subregion 1 and 1990 under the Environmental Quality Plan for tidal flooding (Table 7A.) The total damages, obtained from Figure 1 and displayed in the last column of Figure 7A, is $4,020K. From this, subtract

$750K, the damage abated by structures, as derived from Table 5A and displayed in the appropriate column of Table 7A. The difference is $3,270 K. It is the residual damage, the amount remaining if the proposed structures were in place. Next refer to the evaluation matrix, line 2a(1) and read across to the column labled "Flood proof--voluntarily." The entry is "10/10". As explained earlier, the first digit (in this case they happen to be the same) applies to 1990. Therefore, take 10 percent of the residual damage to get $327K. Rounding it off to the nearest 10, we enter 330 in Table 7A.

Insurance. HUD insurance costs are estimated on the following basis: Assumed that about 50 percent of the expected residual damages will become insured. To insure for $100 in damages, costs are about $40 to the insured and an additional $210 to the government and its agents. This produces a B/C ratio of 0.4 (100 ÷ 250) to society. Of course , this highly subsidized government program is primarily social, not economic, in concept.

13. External benefits and costs are all benefits and costs not computed under Footnote 1 . These externals are assumed to be generally portrayed by all the other criteria in the matrix. Therefore, the ratings on these two lines reflect the general preponderance of pluses and minuses in the applicable column.

14. These entries were specifically prescribed by the PAS. Entry "(3)" is generally a synthesis of earlier benefits, costs and B/C entries. Entry "(4)" is generally a summary of earlier environmental entries.

15. Beneficial effects include contributions to (1) reducing risk of flood, drought or other disaster affecting the security of life, health and safety, (2) reducing the number of disease-carrying insects and related pathological factors; (3) reducing the concentrations and exposure to water and air pollution; and (4) providing a year-round consumer choice of foods that contribute to the improvement of national nutrition.

16. Listed here are the subjects addressed in the 10 LISS planning reports; one has been subdivided into water quality and water supply. An entry reflects a judgement as to whether the net effects of an alternative program will complement (+) or conflict (-) with the listed planning report.

17. A "o" rating reflects the judgement that implementation of the program will require insignificant judicial involvement. A "=" indicates severe judicial problems.

18. If federal action is recommended and non-federal action is more likely and more effective, "=" is entered. Otherwise the entry is "o".

19. If a new institution (new law or new authorization) is not required or, if required, would present little difficulty, "o" is entered. A rating of "=" indicates that a new institution (new law or new authorization) would be required and its creation (passage) would present severe difficulties.

20. Hardly any project or program can be classified as completely oriented toward EQ or ED. Furthermore, almost every alternative can be adapted to minimize its adverse effects with respect to an apparently incompatible objective. For the purpose of subsequent plan formulation, however, some meaningful categorization is desirable here. Five entries were used to reflect this categorization:

    Only EQ - important for EQ reasons, despite significant economic objections.
    Pref. EQ -preferable for EQ reasons, no significant economic objections or preferences.
    Pref. ED -preferable for ED reasons, no significant evironmental objections or preferences.
    Only ED- important for ED reasons, despite significant environmental objections.
    Only SW -not particularly desirable or objectionable for environmental or economic reasons, preferable only for reasons of social well being.

APPENDIX G

OUTLINES OF POSSIBLE FLOOD HAZARD ZONING ORDINANCES[1]

A. DRAFT ZONING ORDINANCE FOR COASTAL FLOOD HAZARD AREAS

1.0 STATUTORY AUTHORIZATION, FINDINGS OF FACT AND PURPOSES
  - 1.1 Statutory Authorization
  - 1.2 Findings of Fact
  - 1.3 Statement of Purpose

2.0 GENERAL PROVISIONS
  - 2.1 Lands to Which Ordinance Applies and Establishment of Regulatory Flood Protection Elevation
  - 2.2 Establishment of Official Zoning Map
  - 2.3 Rules for Interpretation of District Boundaries
  - 2.4 Compliance
  - 2.5 Abrogation and Greater Restrictions
  - 2.6 Interpretation
  - 2.7 Warning and Disclaimer of Liability
  - 2.8 Severability

3.0 ESTABLISHMENT OF ZONING DISTRICTS

4.0 HIGH HAZARD DISTRICT (HH)
  - 4.1 Permitted Uses
  - 4.2 Special Exception Uses
  - 4.3 Standards for High Hazard District Special Exception Uses

5.0 GENERAL FLOOD HAZARD DISTRICT(FH)
  - 5.1 Permitted Uses
  - 5.2 Special Exceptions

---

[1] - These outlines were extracted from a two volume report of the U.S. Water Resources Council (16). The report contains the full text of the two model ordinances plus commentary and numerous other examples and comments. To a community contemplating flood hazard ordinances, the report is a basic reference.

- 6.0 ADMINISTRATION
  - 6.1 Zoning Administrator
  - 6.2 Zoning Permit
  - 6.3 Board of Adjustment
  - 6.4 Hearings and Decisions of the Board of Adjustment
  - 6.5 Special Exceptions

- 7.0 NONCONFORMING USES

- 8.0 PENALTIES FOR VIOLATION

- 9.0 AMENDMENTS

- 10.0 DEFINITIONS

B. DRAFT TWO-DISTRICT ZONING ORDINANCE FOR RIVERINE FLOOD HAZARD AREAS

- 1.0 STATUTORY AUTHORIZATION, FINDINGS OF FACT AND PURPOSE
  - 1.1 Statutory Authorization
  - 1.2 Findings of Fact
    - 1.21 Flood Losses Resulting From Periodic Inundation
    - 1.22 General Causes of these Flood Losses
    - 1.23 Methods Used to Analyze Flood Hazard
  - 1.3 Statement of Purpose

- 2.0 GENERAL PROVISIONS
  - 2.1 Lands to Which Ordinance Applies
  - 2.2 Establishment of Official Zoning Map
  - 2.3 Rules for Interpretation of District Boundaries
  - 2.4 Compliance
  - 2.5 Abrogation and Greater Restrictions
  - 2.6 Interpretation
  - 2.7 Warning and Disclaimer of Liability
  - 2.8 Severability

- 3.0 ESTABLISHMENT OF ZONING DISTRICTS

- 4.0 FLOODWAY DISTRICT (FW)
  - 4.1 Permitted Uses
  - 4.2 Special Exception Uses

- 4.3 Standards for Floodway Special Exception Uses
  - 4.31 All Uses
  - 4.32 Fill
  - 4.33 Structures(temporary or permanent)
  - 4.34 Storage of Material and Equipment

5.0 FLOODWAY FRINGE DISTRICT (FF)
- 5.1 Permitted Uses
- 5.2 Special Exceptions

6.0 ADMINISTRATION
- 6.1 Zoning Administrator
- 6.2 Zoning Permit
  - 6.21 Zoning Permit Required
  - 6.22 Application for Zoning Permit
  - 6.23 Certificate for Zoning Compliance New, Altered, or Nonconforming Uses
  - 6.24 Construction and Use to Be as Provided in Applications, Plans, Permits, and Certificates of Zoning Compliance
- 6.3 Board of Adjustment
  - 6.31 Rules
  - 6.32 Administrative Review
  - 6.33 Special Exception Uses
  - 6.34 Variances
- 6.4 Hearings and Decisions of the Board
  - 6.41 Hearings
  - 6.42 Decisions
  - 6.43 Appeals to the Courts
- 6.5 Special Exception Uses
  - 6.51 Application
  - 6.52 Procedure to be Followed by Board in Passing on Special Exceptions
  - 6.53 Factors upon Which the Decisions of the Board Shall Be Based
  - 6.54 Timing for Acting on Application
  - 6.55 Conditions Attached to Special Permits

7.0 NONCONFORMING USES

8.0 PENALTIES FOR VIOLATION

9.0 AMENDMENTS

10.0 DEFINITIONS

APPENDIX H

"Connecticut's Flood Plain Management Strategy"

27 June 1974

The following appendix is a statement of the State of Connecticut's general strategy on management of the flood plain, and was prepared by the State of Connecticut, Department of Environmental Protection.

Connecticut's Flood Plain Management Strategy

Historically, man has considered dams, dikes, and levees as the best and easiest method to control nature's flood waters. However, in recent years the realization has been brought forth that the flood plain belongs to the river and/or the sea and the emphasis should be to keep structures out of the flood-prone areas and/or provide incentives for relocation. Structural solutions should only be employed in areas where present development is considered too valuable to sacrifice to the natural flood process and in areas where no non-structural solutions are applicable.

This non-structural approach has been endorsed by the National Water Commission, New England River Basins Commission (NERBC) and the Connecticut Department of Environmental Protection.

The following excerpt from a report to NERBC best explains this non-structural philosophy.*

> "The problems of floods and flood related losses have been with us for many years and will continue to be with us as long as we, society, and the rivers choose to use the same lands for our different purposes. This conflict occurs within the flood plain land of our rivers and streams. If man and his artifacts were not in the flood plain the river would have its way; no "damages" would occur; and the "problem" would not exist. Conversely, if the river was made to stay within the confines of its banks the problem would also no longer exist.
>
> Traditionally, man has looked upon flood damage control from the standpoint of controlling the river. Dams to store and control flood water flows, and dikes and levees to hold back the river have frequently been the solutions. But their effectiveness is limited. Sooner or later, along comes the flood that simply can't be contained. To compound the problem, in the meanwhile, Man has increased his use of the flood plain now that it is a "safer" place. So, as flood damages continued to mount in spite of the public dollars expended for protection, officials began to seek other ways of managing flood damages.

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*"Report to NERBC on Non-Structural Measures for Flood Plain and Flood Management". by Cheney, Miller, Ellis

> The most common statement of the alternatives for control of flood damages describes them as:
>
> 1. "keep the river away from people and their structures and activities" or
>
> 2. "keep people, their structures and activities away from the river"
>
> The first is carried out by structural means which control flow (dams, dikes, levees, etc.) and the second by nonstructural means which control people's activities (zoning, acquisition, etc.)."
>
> Non-structural measures influence flood losses in two general ways. First, there are measures which directly reduce losses or at least transfer the incidence of such losses to a broader portion of society. For example, flood insurance subsidized by the Federal Government, while it does not eliminate losses, does distribute the costs; flood proofing of structures reduces directly the potential flood-caused losses; flood plain zoning, subdivision regulations and the like reduce potential losses by prohibiting the development of flood prone areas by potentially flood-sensitive activities."

The other way in which non-structural measures control losses from river flooding is by limiting the effects of filling and development on flood heights. Non-structural measures seek (1) to preserve natural storage of flood waters within the basin and (2) to limit the backwater caused by development. Placing fill on flood plains reduces the volume of water which may be temporarily stored during a flood. The effect on the discharge from a basin for any given flood is to increase the magnitude of the peak flow and to reduce the time it takes for the flood crest to travel through the basin. Shortening the crest travel time will cause the flood creast of the main river to coincide more closely with the arrival of peak flows from tributaries. The result is to produce higher flood elevations downstream than would be experienced if the basin remained unfilled. The second effect of filling flood plains is to constrict the flow of the river by reducing the cross sectional area of the flood plain available for passage of flood waters. This may result in additional flooding upstream from the filling.

Thus, by regulating the placement of fill and other obstructions in flood plains, excessive increases in flood heights upstream and downstream are limited. Coastal flood plains are similarly incompatible with excessive development; here, structures are threatened not only by storms and high water, but by the natural processes of erosion and movement of sand and sediment. Again, unwise use merely invites long-term loss or disaster. Table I from the Cheney, Ellis, and Miller report lists non-structural flood control measures which are discussed in detail in the main report.

This non-structural approach to flood plain management is presently being pursued in Connecticut under the following Acts:

(1) Stream Channel Encroachment Act

(2) The Inland Wetlands and Water Courses Act

(3) The Tidal Wetlands Act

All State flood controlprojects are analyzed for possible non-structural alternatives and the Connecticut Department of Environmental Protection stresses flood plain management as part of all the Soil Conservation Service small watershed projects undertaken in Connecticut.

Connecticut believes that the flood plains belong to the river, that the flood plain is a vital link in the annual flood cycle and that unnecessary flood plain development results in increased annual flood damages and flood heights. Similarly, the tidal marshes, barrier beaches, and other low-lying coastal areas of Connecticut are vital elements of the coastal environment; they also become flooding liabilities if unwisely subjected to development.

Connecticut will therefore continue to stress non-structural

TABLE I

NONSTRUCTURAL TECHNIQUES FOR FLOOD MANAGEMENT *

I. TECHNIQUES TO LESSEN THE IMPACT OF FLOOD DAMAGES
  - A. Flood Insurance
    - 1. Subsidized
    - 2. Compulsory
  - B. Emergency Relief
  - C. Flood Forecasting and Warning

II. TECHNIQUES TO MODIFY SUSCEPTIBILITY TO FLOODING
  - A. Acquisition
    - 1. Complete
    - 2. Partial
  - B. Evacuation
    - 1. Permanent
    - 2. Emergency
  - C. Urban Renewal and Redevelopment
  - D. Flood Proofing
  - E. Control of Utility Locations
  - F. Cluster Zoning and Planned Unit Development
  - G. Flood Plain Zoning
  - H. Wetland Protection Laws
  - I. Compensable Regulations
  - J. Building Codes
  - K. Subdivision Regulations
  - L. Encroachment Lines

III. TECHNIQUES TO PROVIDE INCENTIVES TO IMPLEMENT NONSTRUCTURAL TECHNIQUES
  - A. Cost Sharing
  - B. Subsidies
  - C. Tax Adjustments
  - D. Special hazard assessments
  - E. Density transfer
  - F. Internalization of costs

* Cheney, Ellis and Miller report

techniques in its flood plain management policies and programs. This policy involves both the careful regulation and control of development in flood hazard areas and the promotion of riverine and coastal flood plains for their most compatible and ultimately, most beneficial uses. Encouraging the use of flood plains for agriculture, open space, parks and recreational areas, while at the same time regulating development, will in the long run limit flood damages, while providing a maximum return to the citizens of the state.

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LONG ISLAND SOUND REGIONAL STUDY
As of the date of this report

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Primary responsibility for these planning reports rests with the chair agency indicated above. The other agencies and individuals listed participated either in an active, a review, or an advisory role, but their listing here does not necessarily imply an endorsement of the report in whole or in part.